Popular Astronomy.

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THE TOTAL ECLIPSE OF MAY 28, 1900.

WILLIAM H. PICKERING,

For Popular Astronomy.

It does not appear to the writer that direct photographs of the solar corona have very much scientific importance. He is inclined to believe that their chief value is an aesthetic one. If well taken, they form attractive souvenirs of what is undoubtedly one of the grandest celestial phenomenon on which the eye of man has ever rested. It is this aesthetic enjoyment attained, which it seems to him will constitute the chief gain of the majority of the expeditions which will view the eclipse this next May.

If photographs are of little value, it may safely be said that drawings are worse than useless, since it is quite impossible during the brief time available during totality to represent, with the least pretentions at accuracy, even a very restricted area of the corona. Meanwhile, the time spent in looking at the paper might much more profitably be expended in watching the eclipse itself. It is therefore recommended to those who visit the eclipse region at their own expense, to spend but little time in attempts at scientific work. Probably the most valuable thing that can be done by the average person, especially if off the central line, is to note the duration of totality. This may best be done with a stop watch, but any watch furnished with a second hand may be used, and an effort should be made to determine the time correctly, within half a second. An accurate description of the location of the station should be prepared as described in the recent publication of the Naval Observatory, and sent to the proper authorities.

For those who are so fortunate as to be within the darkened region, one of the grandest features to be seen will be the on-rush of the Moon's shadow. It approaches with approximately the speed of a cannon ball, and is a very striking phenomenon. Since, however, it comes from the west, while the Sun is in the east, one cannot watch both at the same time, and it is recommended to those who are seeing a total eclipse for the first time to be satisfied with watching the shadow depart at the end of totality, and

not miss the flash of the corona at the instant totality comes on.

Each observer should have some aid to the eye-sight, if it is only an opera glass. Great care should be taken not to dazzle the eyes by watching the Sun too long during the partial phase, not only on account of the danger of straining the eye-sight, but also because if the eyes are dazzled the corona will be less well seen. A combination of red and green glasses, or red, green and blue, makes a satisfactory shade for the eyes, and it can hardly be too dark. During totality no shade will be needed.

If a sheet be spread on the ground one may watch the shadow bands which appear for a few seconds before and after totality. They are still sometimes erroneously spoken of as diffraction bands, although, of course, they have really nothing whatever to do with diffraction itself. They are due to atmospheric waves occurring a few thousand feet above the Earth's surface at the contact of two currents of air flowing with different velocities. Their direction and speed are dependent on the wind, and have no connection with the Moon's motion or shadow. We may produce the phenomena at will any cold night, by opening a window near an electric arc light, when the shadow of the rising hot air currents may be seen cast on a sheet of paper.

During totality it is so dark that first and second magnitude stars appear, but stars of the third magnitude are seldom if ever visible to the naked eye. I have never seen it so dark that there was even the slightest difficulty in reading the time from a watch of ordinary size. Those interested in the matter will find various suggestions both for visual and photographic observations given in the Harvard Annals, Vol. XVIII, p. 109.

Although, as remarked at the beginning of this paper, little of scientific value can attach to direct photographs of the corona, still many observers will wish to bring away with them some reminder of their trip, however inadequate it may be to represent the grandeur of the phenomenon witnessed. In order to obtain the best results the following facts should be borne in mind: The diameter of the image of the Moon is about one one-hundredth of the focus of the lens. The brightest part of the corona is about one-fiftieth of the photographic brightness of the full Moon. The faintest part of the corona, which is equal in brightness to that of the surrounding sky, is about the same as that of the sky at evening, when second magnitude stars first become visible. The Moon itself is absolutely black, and no one has as yet succeeded in seeing or photographing any detail upon it.

This blackness of the Moon in comparison with the sky is not a

contrast effect, as might at first be supposed, but is a real phenomenon, as is shown by photography. It is not generally recognized, I believe, that it indicates that the general illumination of the heavens surrounding the corona is due to a source of light beyond the Moon. That is to say, this general illumination is not due to the light of the inner corona reflected from our atmosphere, nor yet to the illumination of our atmosphere by the bright regions of the Earth's surface outside of the Moon's shadow, but is due to the reflection of the Sun's light from the countless small bodies revolving about it, and lying chiefly inside of the Earth's orbit.

It has been found at Harvard that upon the average night, when the object is sufficiently brilliant, as in the case of the Moon and brighter stars, better definition is obtained with a photographic telescope of fourteen feet focus when aperture is cut down to 3.5 inches, than with either larger or smaller apertures. During totality the seeing is likely to be worse than during the night at Cambridge, therefore for most purposes we may take three inches as the maximum size desirable for photographic use. It is only with instruments of very long focus that a larger size is necessary, and we are then liable to secure inferior definition, together with a lack of contrast on account of the large scale employed.

Nearly all the detail of the corona lies in a radial rather than a tangential direction. The brightness of the corona varies rapidly radially, but only slightly at right angles to this direction. Therefore, if we wish to bring out the radial structure, we must use a plate giving great contrast, but in so doing we limit ourselves to a zone of small breadth surrounding the Moon. Inside of this zone the corona is over exposed, outside of it the corona is under exposed. On the other hand, if we use a plate having great range but little contrast, the whole corona may be shown upon it properly exposed, but little detail will be seen in any portion of its area. Efforts have been made to overcome this difficulty by shutters especially devised to vary the exposure in different portions of the field. In any case the photographer is advised to use a plate giving great contrast, which is equivalent to using a very slow plate, such for instance as is used for lantern slides and process work.

With an ordinary telescope, whose focus is sixteen times its aperture, an exposure of two seconds will give a very satisfactory picture of the inner corona. If one is provided with a mounting driven by clock work the longer the focus the better. If no clockwork is employed, and the focus is as much as four feet, the ex-

posure should not exceed one second, or the trailing of the image will become apparent. For the best results in photographing the outer corona a slow plate is imperative. With a doublet whose focus is six times its aperture, an exposure of ten seconds is about right. One must not make the mistake of giving too long an exposure, or the plate will be over-exposed, and little contrast secured. It is probable that the outermost regions of the corona that we can observe can best be photographed with a lens of only a few inches focus. Thus, in 1886, with a lens of eight and a half inches focus, the corona was traced for 90′ from the Moon's limb, although all distinct detail ceased at a distance of 60′ (Harvard Annals, Vol. XVIII, p. 108). This is believed to be the greatest extent of corona shown by photography up to that time, and it has only recently been exceeded by photographs taken during the Indian eclipse of 1898, when a similar lens was used. All the plates should be backed with suitable varnish to prevent reflection from the rear of the plate. A water color backing is of no use, since the index of refraction of the drying medium must equal that of the glass.

HARVARD OBSERVATORY, Cambridge, Mass.,
March 26, 1900.

S. W. BURNHAM'S NEW DOUBLE-STAR CATALOGUE.* A REVIEW.

R. G. AITKEN.

FOR POPULAR ASTRONOMY.

"A general catalogue of all the double stars discovered by me from time to time during the past twenty-five years has long been needed by those interested in this field of astronomical research, and by reason of the special interest attached to many of these remote sidereal systems, it has become more and more important to bring the scattered material together in order to intelligently pursue the investigations which promise to so much increase our knowledge of the great universe beyond the solar system." These words, taken from Mr. Burnham's introduction, give the raison d' être of the work of which, at the request of the editor of POPULAR ASTRONOMY, I am glad to write this review.

* [Publications of the Yerkes Observatory, Volume I, 1900. A General Catalogue of 1290 Double Stars discovered from 1871 to 1899 by S. W. Burnham. Arranged in order of Right Ascension with all the micrometrical measures of each pair, by S. W. Burnham, Chicago. The University of Chicago Press, 1900.

The merit of the volume from the mechanical stand-point will appeal to all who are interested in good book-making. The large open quarto page is well adapted to such a work, and the clear type, the wide margins and the almost complete absence of typographical errors combine to make it attractive to the eye. An excellent view of the Yerkes Observatory forms a fitting frontispiece, and the introduction is illustrated by good engravings of the great 40-inch refractor of that Observatory and of the three telescopes with which the greater part of Mr. Burnham's work has been done—the famous 6-inch refractor, the 18½-inch of the Dearborn Observatory and the 36-inch of the Lick Observatory.

In this introduction, Mr. Burnham gives an account of the beginning of his astronomical work, which will be of interest to many who may not see his volume. "When in London," he says, "about 1861, I purchased one of the cheap astronomical telescopes introduced about that time. It had a nominal aperture of three inches, but was without a finder, and had only the simple alt-azimuth mounting with a common table tripod. It was supplied with a terrestrial, as well as astronomical, eyepiece and while it was a good instrument for landscape use, it was of little value for astronomical purposes. Some years later I obtained a 3¾-inch telescope, with an English object-glass, mounted equatorially by Fitz on a portable stand. This was just good enough to be of some use, and poor enough, so far as its optical power was concerned, to make something better more desirable than ever. In 1869 I accidentally met Mr. Alvan G. Clark in Chicago . . . . . and made some inquiries of him about a small equatorial. This interview resulted in my ordering from the celebrated firm of Alvan Clark and Sons an equatorial of six inches aperture. I told them what I wanted and what I wanted it for. Every detail was left entirely to their judgment, stipulating only that its definition should be as perfect as they could make it, and it should do on double stars all that it was possible for any instrument of that aperture to do. In due course of time this instrument was delivered, and was set up in an observatory prepared for it in the mean time. My attention for some reason or other, which I am unable to explain, had been almost exclusively directed to double stars previous to this while using the smaller telescopes referred to. This preference was not in any sense a matter of judgment as to the most desirable or profitable department of astronomical work, or the result of any special deliberation upon the subject. It came about naturally, without any effort or direction upon my part."

With this instrumental equipment and an astronomical library consisting principally of the first edition of Webb's Celestial Objects for Common Telescopes, Mr. Burnham began his work. His first new double star (β 40) was found on April 27, 1870. By correspondence with other observers, both amateur and professional, by queries in the columns of the *English Mechanic*, but principally by the laborious process of *copying the lists of double stars* from various publications loaned him by different astronomers, he managed to increase his knowledge of the work of previous discoverers in this field to such an extent that in 1873 he was able to publish a catalogue of 81 double stars which he confidently believed to be new.

This modest little list of stars found by an amateur with a six-inch telescope, forms a striking contrast to the present volume, issued as the first publication of a great Observatory, with its 1290 stars, and its summary of thousands of measures, the work of many of the best observers and most powerful telescopes of modern times. Yet the early publication contained the promise and potency of the larger work, for an analysis of its 81 stars shows that 40 of them are separated by distances of 2″ or less—4 of them being well under 1″—and that 9 are naked eye stars. Thus two characteristics of the β stars were at once manifest. The third characteristic of all of Mr. Burnham's catalogues, also holds for this first one, for at least 15 of the 81 stars have now given evidence of being physical systems.

It is a matter for congratulation that Mr. Burnham refused to be discouraged by the belief which seems to have been general amongst astronomers in 1870, that the field of double-star discovery had been exhausted by the Herschels and Struves. Even so well informed a man as the Rev. T. W. Webb, writing in 1873, after the first three catalogues of β stars had been published, said: "It will hardly be possible for you to go on for any great length of time as you have begun, because the number of such objects is not interminable, and every fresh discovery is one less to be made. Still, what you have already done is so much more than any man now living has accomplished, that your high position as an observer is fully secured." After quoting this passage Mr. Burnham remarks: "Since that time more than one thousand new double stars have been added to my own catalogues, and the prospect of future discoveries is as promising and encouraging as when the first star was found with the six-inch telescope."

It is not my purpose to enter into the detailed history of Mr.

Burnham's labors in this field. As is well known, he continued his work of discovery with the six-inch glass, and such larger instruments as became available, until he had published 19 separate catalogues, containing 1274 objects. While preparing the present volume he added 8 pairs found with the 40-inch telescope and recovered 8 others, previously overlooked, from his old observing books. This brings the total to 1290; but 13 stars were later found to be identical with previously known pairs, and their numbers, with the number 444, accidentally omitted, do not appear in the General Catalogue. One thousand, two hundred and seventy-six pairs are therefore given; 133 of these consist of additions of closer or more difficult components to previously known double stars, and 291, nearly one-fourth of the whole, are bright enough to be visible to the naked eye.

The arrangement of these stars in the General Catalogue leaves nothing to be desired. They are given in the order of right ascension (for 1880.0) with all the measures of each pair to the end of the year 1899. The measures are mean results, giving the date, the position-angle, the distance, the observer, and the number of nights on which complete measures were made—"in many instances the angle has been measured on a greater number of nights than that given here." A sufficient number of the estimates of relative magnitude made by different observers is given to fix this quantity with all necessary accuracy. The notes to each pair state the telescope with which it was found, the character of the relative motion, if any, the amount and direction of the proper motion of the primary from meridian observations, if it has been determined, and in the cases of the more interesting stars, a more complete discussion, with the data of orbits, when such have been computed, and other information of value to the observer or computer. In this connection diagrams are freely used. Finally, a complete reference list of the original publications of measures is appended to each star.

But one who reads the book carefully cannot fail to notice Mr. Burnham's moderation in the way of descriptive writing, and his economy in the use of adjectives, especially of those in the superlative degree. One notes these facts with a distinct sense of pleasure, for what is wanted in a work of this kind is the description and history of each star as complete as possible, but in compact form.

In his Introduction, Mr. Burnham shows that all the leading double star catalogues prior to 1870 contained only 680 stars

with distances not exceeding 2″. His own discoveries have added not less than 690 to this class. If we extend the comparison to some more recent catalogues, we shall find that 248 of Hough's 622 stars, and 162 of See's 500 have measured distances of 2″ or less. Neither catalogue will compare with Burnham's in the proportion of close pairs. We cannot speak with certainty of Innes' stars for hardly any of them have been measured, but apparently about 200 of the 300 pairs fall into this category. If we assume 300 other pairs—a very liberal estimate—of this class as the contribution of all other observers to the present time, the β stars still give us 30 per cent of all known close double stars.

The significance of this statement—aside from its testimony to the keen observing powers of their discoverer—lies in the fact that the class of close double stars yields by far the greater proportion of physical systems, and practically all the binary stars of short period. In the present state of our knowledge, the period of revolution of a double star, in its most interesting and most important feature, and the shorter the period, the higher the interest. Some hundreds or thousands of years hence, when the accumulated observations of generations of astronomers have furnished sufficient data for the determination of a large number of orbits, greater interest may attach to other elements—the eccentricity, for instance. But even so, it is obvious that the stars in rapid motion will yield the necessary observations in the shortest time; and the great importance of the β stars is due to the fact that many of them are already recognized as binaries of very short period, and that many others give evidence of being in rapid motion.

Mr. Burnham lists 185 pairs (about 14 per cent of all the β stars) that have so far given more or less evidence of being physical systems. He warns us that this list is only provisional. In some cases the relative motion is too small to make the nature of the change certain; many other stars have been observed at but two epochs, separated in some instances by only 5 or 6 years; and about 40 pairs have not been re-measured since discovery. 16 of the last named number are the late additions, and a few others may ultimately prove to be single. How many binaries may later be added from these three classes it is of course impossible to say. An examination of the 185 pairs at present enumerated as physical systems, shows that 41 of them are included largely on the ground of possessing a common proper motion, though there is also slow relative change. These

pairs are all at least moderately close—several of them very close. 52 other pairs are relatively fixed, but possess a common proper motion. Only seven of these are as wide as 10″, and 33 of them are closer than 5″. For all the pairs under—say 5″—a common proper motion is sufficient evidence of physical connection through an attracting force similar to, if not identical with, that of gravitation. When the angular separation of the two stars is great, we cannot speak so confidently, but even then the best we can do is note the pair as *probably* a physical system, leaving definitive classification to the future.*

No one will question the correctness of Mr. Burnham's classification of the stars just mentioned except perhaps in a few instances where the amount of the proper motion is very small—as for example β 63 and β 1090. But the other stars, those that show decided relative change are of far greater interest. Some of these also possess common proper motion and in but few cases is the orbital nature of the motion in doubt. In at least 27 of these pairs, the motion has been so rapid that the period of revolution is almost certainly less than 50 years; and there are fully a dozen more very interesting systems with moderately short periods. The observations of the next few years will in all probability considerably increase the numbers in both of these classes.

A review of all the double stars for which orbits with periods of less than 50 years have been computed, shows that the great Σ catalogue has contributed five—only one of which, Σ1728, has a period of less than 30 years. The *O* Σ lists add two—*O* Σ 269 (49 years), and the remarkable system of δ Equulei, which needs only 11.5 years for a revolution; and the discoveries of Alvan Clark and Alvan G. Clark, three more (adopting Zwiers' period for Sirius), all with periods over 30 years. The 19 year period star ζ Sagittarii, discovered by Winlock, brings the total number of short-period binaries, exclusive of the β stars, to eleven, only three of which complete a revolution in less than 30 years. It is probable that Procyon, 95 ceti, and ε Hydrae *AB*, discovered respectively by Schaeberle, Alvan Clark and Schiaparelli, will later be added to this number.

Turning now to the β stars, we find $\varkappa$ Pegasi (11.42 years), the most rapid binary whose period is accurately known, five pairs with periods between 15 and 30 years, and two more with periods under 40 years. For these stars orbits have been compu-

[* In this connection see Burnham's article "The Binary Systems" in POPULAR ASTRONOMY No. 34.]

ted. We have also β 555 and β 639, which are certainly very rapid, and many other systems (*e. g.* β 552, β 648, β 962, β 1077, etc.), whose periods will prove to be short.

Mr. Burnham's opinion of the value of double star orbits based on short arcs is well known, and it is therefore not surprising to find that he has computed but two orbits for his General Catalogue. For β Delphini (β 151) he finds a period of 26.70 years—a year shorter than that assigned to it by See—and for 85 Pegasi (β 733) a period of 25.7, which is 1.7 years longer than the one given by See. The other elements also vary somewhat from See's, the semi major axis and inclination of both orbits being considerably smaller. Of β 416, for which five orbits, with periods ranging from 25 to 35 years, have been computed, Mr. Burnham says: "While the general form of the apparent orbit is fairly well indicated, an investigation of this time could give only a provisional value. A revolution will soon be completed, and then a reliable determination of the elements can be made."

This conservatism also prevents him from making any more definite statements with regard to such stars as β 524 and β 612 than that orbits have been computed, but are uncertain; that the motion is rapid, and that the measures of the next few years will probably furnish data for reliable conclusions.

Of β 395, Mr. Burnham writes: "See, using the measures to 1897.67, has computed the orbit and found a period of 16.3 years (*A. N.* 3455). This assumes a change of about 180° between 1891 and 1897. From the slow motion in angle and distance between the date of discovery and the last measure in 1891, it seems very probable that in all the observations the companion star should be put in the same quadrant. . . . . There is no question of the binary character of this pair, but if the change has been in a gradual approach of the two components, as seems most likely, the period will not be a short one." And of β 885, for which Glasenapp has found a period of 16.88 years, and See one of 5.5 years, he writes (Appendix, p. 293): "A recent examination of all the measures of this star leads to the conclusion that the most probable period is about seventeen years. It is certain that the measures of 1891.97 to 1899.78 are properly adjusted as to quadrants, and that the angular motion in 7.8 years is only 110°.

All these matters are questions to be settled by the observer, and answers should be forthcoming in a very few years. Meanwhile, the most satisfactory attitude, and, in my opinion, the one most conducive to real progress, is the conservative one which Mr. Burnham takes.

I cannot close this review without calling attention to a matter that does not strictly relate to the β stars:

It has long been known to double star observers that Mr. Burnham is in possession of more extensive and more accurate knowledge of the bibliography of double star astronomy than any other man living; and that he has used his knowledge in compiling a complete catalogue of all double star discoveries and measures. In the introduction to his present volume he refers to this, saying that the catalogue, which is arranged in proper form for printing, "has all the time been kept posted to date, by the addition of all new material as soon as printed, and many unpublished discoveries and observations." He adds: "Whether it will ever assume other than the present manuscript form remains to be seen."

The publication of such a catalogue would do for all double stars what his present volume does for the β stars. Nothing else could do so much to stimulate research and to direct observers to fruitful fields of labor. It appears to me to be the most urgent need of double star astronomy today, and I am confident that I voice the sentiment of double star observers everywhere in expressing the hope that the means may soon become available to put this work—the result of years of patient labor, into the permanent form now assumed by the General Catalogue of the β Stars.

LICK OBSERVATORY, University of California.
March 6, 1900.

THE LATE CATHERINE WOLFE BRUCE.

W. W. PAYNE.

It is no easy thing to choose fitting words to refer to the close of any life on Earth, much more is it difficult to offer a right and worthy tribute to the memory of one like Miss Catherine Wolfe Bruce, who, for noble cause, the world of science has learned to love for what she was and for what she did.

In what follows it is plain that her intelligent generosity knew no limits of race or country, and so science the world over mourns a common loss. Her kind and thoughtful care lightened many a burden in her own land, awakened new zeal in needful research, and helped to finish many a task when patience and other resources were nearly gone.

Too much will not be said in honor of such gentle and unpre-

tentious worth; for, of such kind is greatness that lives on in unfailing strength and beauty, through the finite and changeful here into the blessed real and eternal yonder.

Miss Bruce was born Janury 22, 1816. Her home was No. 810 Fifth avenue, New York City, at which she was during her last long illness. She passed away March 13, 1900.

We are indebted to a friend for a brief notice of the sad news which appeared in a recent issue of the New York *Tribune*, as follows:

"Miss Catherine Wolfe Bruce deserves more than the ordinary obituary record, for she was a woman of the highest character, of many and varied accomplishments, and had contributed nobly of her means to the cause of charity, of education and of science. The George Bruce Free Library she built, established and endowed, and it is today one of the most flourishing branches of the free library system. Her benefactions to the cause of astronomy are known all over the world, and her name is identified with many important advances in that science. She corresponded with eminent professors here and in Europe, and was the recipient of distinguished honors for her interest and service. A gold medal was presented to her by the Grand Duke of Baden, and she enjoyed the signal distinction of having her name given to a newly discovered asteroid.* Upward of $200,000 has been her contribution to the science she loved. Her charitable gifts and those of private benevolence need not be mentioned here.

"Miss Bruce was the daughter of George Bruce, the famous type-founder, whose work has stood the test of time and change, and is still in use at the present day. Naturally, Miss Bruce was interested in the art of printing—that 'art preservative of all arts,' as she was fond of quoting. It has been said that Miss Bruce was an accomplished woman. She had made a study of painting, and was a painter herself. She knew Latin, German, French and Italian, and was familiar with the literature of those languages. She wrote and published in 1890 a translation of the Dies Aræ. For many years she was an invalid, and deprived of that society which her talents and character well fitted her to adorn. She was always patient and uncomplaining, and entirely resigned to the will of the Almighty Disposer of Events. She has left a gracious memory of good and generous deeds and an impressive example of noble womanhood."

In answer to our request a personal friend has favored us with a list of the generous benefactions made by Miss Bruce to advance the interests of astronomy. It is a pleasure to publish the entire list:

* No. 323.

GIFTS TO ASTRONOMY.

June 19,	1889	—Harvard College, on account	$ 25,000
July 29,	1889	—Harvard College, in full	25,000
Sept. 25,	1890	—Professor Hirsch, Neuchatel Inter. Geodetic Association,	500
Oct. 1,	"	—Professor W. W. Payne, Carleton Observatory	250
" 6,	"	—Professor Simon Newcomb, Washington Nautical Almanac	500
" 9,	"	—Dr. Ludwick Struve	500
" 9,	"	—Dr. David Gill, Cape Good Hope	500
" 9,	"	—Professor J. C. Adams, London	500
" 9,	"	—H. H. Turner, Oxford	500
" 13,	"	—Henry A. Rowland, Baltimore	500
" 13,	"	—Professor E. S. Holden, Lick	500
" 25,	"	—Professor J. J. Astrand, Norway	150
" 25,	"	—Dr. J. Plassmann, Warrendorf, Germany	100
" 25,	"	—Professor H. Bruns, Leipsic, Germany	500
Nov. 7,	"	—Professor A. Safārik, Prague	450
" 7,	"	—Professor Lewis Swift, Warner Observatory, Rochester,	50
" 9,	1891	—Harvard College	500
June 1,	1892	—Dudley Observatory, Albany, Professor Lewis Boss	25,000
Oct. 10,	1893	—Dudley Observatory, Albany, Professor Lewis Boss	10,000
Ap'l 17,	1894	—Professor Max Wolf, Heidelberg	10,000
May 3,	1895	—Chamberlin Observatory, H. A. Howe	1,000
" 15,	"	—Edw. S. Holden, Lick	500
Sept. 13,	"	—E. E. Barnard, Lick Observatory	500
Nov. 22,	"	—George E. Hale, Astrophysical Journal	1,000
Mar. 19,	1896	—Professor L. Weinck, Prague	300
June 8,	"	—Mary W. Whitney, Vassar Observatory	350
" 23,	"	—Leo Brenner, Manora Observatory, Lussinpiccola, Istria,	1,650
July 28,	"	—Edw. S. Holden	1,000
Dec. 7,	"	—Vassar College, Maria Mitchel Memorial	1,000
Feb. 2,	1897	—Professor L. Weinck, Prague Royal Observatory	1,000
Ap'l 16,	"	—H. A. Howe, Astronomical purposes Chamberlin University, Denver	2,600
May 17,	"	—J. K. Rees, Columbia University (publication)	1,500
July 22,	"	—E. E. Barnard, Yerkes Observatory, Photo-Telescope	5,500
" 22,	"	—E. E. Barnard, Observatory	1,500
" 26,	"	—Edw. C. Pickering, for printing J. G. Hagen's charts of Variable Stars, in five series, Georgetown College Observatory, D. C.	1,750
Sept. 2,	"	—F. R. Ziel, Secretary and Treasurer Astronomical Society of the Pacific Ednowment Bruce Medal	2,750
Nov. 26,	"	—Professor Rees, Columbia University, to pay salary of computors for one year	1,600
Jan. 4,	1898	—Professor Dr. L. Weinck	500
Mar. 4,	"	—E. E. Barnard, publication Double Stars	1,500
May 31,	"	—Herman S Davis, Reduction Piazzi's Observations	575
June 7,	"	—Columbia University, salary Dr. Hill, Celestial Mechanics, for five years	5,000
" 24,	"	—Yerkes Observatory, salary Professor Frost, Astrophysics, five years	15,000
Aug. 19,	"	—Astronomical Clock for J. G. Hagen (remitted Professor Pickering)	500
Sept. 28,	"	—H. A. Howe, salary for one year	2,000
Oct. 13,	"	—J. K. Rees, Telescope Hellsingfors Observatory	2,500
" 13,	"	—J. K. Rees, to pay salary of computors for one year	1,500
" 13,	"	—Herman S. Davis, Reduction of Piazzi's Observations	600
Dec. 19,	"	—Simon Newcomb, salaries Computors Ultra Neptunian Planet	600
Mar. 17,	1899	—Publication of Father Hagen's Chart (Remitted Professor Pickering)	1,400
Ap'l 5,	"	—J. K. Rees, Columbia College, for measurement and discussion of Astronomical Photographs	10,000

Sept. 8,	"	—George E. Hale, for Spectograph for Yerkes Observatory,	2,300
" 14,	"	—H. A. Howe, salary for one year	2,000
" 27,	"	—William R. Brooks, manufacturing Astronomical Instruments	300
Nov. 29,	"	—Beloit College, Department Astronomy	1,500
			$174,275

A NOTE ON A SUPPOSED EARLY CONJUNCTION OF PLANETS.

W. H. S. MONCK.

FOR POPULAR ASTRONOMY.

The late Mr. John Williams, in his *Observations of Comets*, (extracted from the Chinese Annals), published in 1871, gives some interesting details as regards early Chinese Astronomy which he had carefully studied. One of these relates to the conjunction of planets to which I refer.

"In the Chinese Annals it is recorded that in the reign of Chuen Kuh, the grandson of Hwang Te, in the spring of the year, on the first day of the first Moon, a conjunction of five planets occurred in the heavens in Ying Shih. Zing Shih, or as it is more usually denominated Shih, is one of the 28 stellar divisions, determined by α, β and other stars in Pegasus, extending north and south from Cygnus to Piscis, Australis, and east and west 17 degrees, and compasing part of our signs Capricornus and Acquarius. The Emperor, Chuen Kuh, is said to have reigned 78 years, from B. C 2513-2436, and to have died in his 97th year; and from modern computations (I believe by Bailly, the French astronomer), it has been asserted that a conjunction of the five planets actually did take place about the time and within the limits indicated, *i. e.* on the 29th of February, 2449 B. C., being the 65th year of Chuen Kuh. Should this on further investigation prove correct, it will afford a strong presumption of the authenticity of the early Chinese annals, as there is no appearance of these astronomers having been at any time able to compute the places of planets so far back; and the account is to be found in works published long before any intercourse with Europeans had taken place."

The length of Chuen Kuh's reign is a little startling, and leaves a good deal of scope for such a conjuction, and if really observed, it seems strange that the first comet in Mr. Williams' catalogue should be in B. C. 611, or more than 1800 years after the conjunction of planets had been observed. But, turning to a well known work on the subject, Mr. G. F. Chambers' *Handbook of Astrono-*

my, I find (Vol. I. pp. 70-1) that he speaks of the conjunction as one of Mars, Jupiter, Saturn and Mercury, and says that Desvignoles and Kirch computed that such a conjunction actually did take place on February 18th B. C. 2446, between 10° and 18° of Pisces. Williams, however, though he may have made a slip in the date, when citing Bailly from memory, is very unlikely to have misrepresented the Chi ese annals as stating that there was a conjunction of the five planets if only four were mentioned (and these four, it would seem, specified if Chambers be correct). Chambers consulted both Bailly and the original memoirs of the two computers in question. He goes on, however, to mention a third computer, de Mailla, who places the same four planets together with the Moon in conjunction between 15° and 27° Pisces on the the 9th of February, B. C. 2441. But the Chinese observers would hardly have described the Moon as a fifth planet, and it will be noticed that Venus, the brightest of all the planets is represented as being on both occasions conspicuous by her absence. But three conjunctions of the remaining four planets in February, 2441 B. C., 2446 B. C. and 2449 B. C., in the same part of the sky are, I apprehend, simply impossible. If one of these conjunctions took place the other two did not. Even if a conjunction of four planets would satisfy the Chinese record, can we rely on its occurrence, when three computers give us three inconsistent dates?

But some other dates given by Mr. Williams are rather startling. The system of reckoning by cycles of 60 years was introduced, he states, by the Emperor Hwang Te, who reigned for 100 years, from 2698 B. C., to 2598 B. C. Chuen Kuh was his grandson. The time that elapsed between the accession of the grandfather and grandson was just 185 years, after which it will be recollected the latter reigned for 78 years, making 262 or 263 years from his grandfather's accession to his death. Mr. Williams does not give any particulars as to Chuen Kuh's immediate successor, but it seems that the Emperor Zaou, also reigned for 100 years, from 2356 B. C. to 2256 B. C. I presume the length of Zaou's reign was taken into consideration in computing the time when Chuen Kuh lived. The impartial reader will, I think, entertain a very strong suspicion that the whole of this historical chronology is fabulous; that very probably there never was any such Emperor as Chuen Kuh; that if he really existed, the date of his reign is extremely uncertain; and consequently that the conjunction of planets was not recorded by any observer, but arrived at by computing backwards, in the very same way that the European astronomers of the 18th century arrived at a similar result.

The Chinese astronomers also computed a conjunction for some date between 2513 B. C. and 2436 B. C., and then following the current but fabulous history, ascribed it to the reign of Chuen Kuh. The problem was probably suggested by an observed conjunction of three or four planets in this region of the sky. A rough computation would enable an astronomer to calculate the dates when the same planets had come together in the same part of the sky during past ages, and then the question was, at which of these dates were the remaining planets, or one of them, also to be found in same constellation? This was computed, but very probably computed erroneously. Such I believe was the history of this conjunction.

THE TOTAL SOLAR ECLIPSE, MAY 28, 1900.

H. C. WILSON.

The great astronomical event of the year, at least so far as can be predicted, is to be the total eclipse of May 28, which will be visible in accessible regions, both in America and Europe.

In Europe the path of totality passes across Spain and Portugal, touching a number of easily accessible cities. It also crosses the northern coast of Africa, the two large cities, Algiers and Tripoli, lying near the central line. Many European expeditions will occupy stations along this portion of the path of the Moon's shadow. The eclipse committee of the British Astronomical Association have undertaken a steamer excursion to Spain and Algeria. The steamer proposed will carry 189 passengers, and the cost to one making the entire trip to Algiers and remaining on board during the stay is to be 22*l.* 10s. At latest reports, the war in South Africa makes it somewhat doubtful whether the requisite number of persons will go to make the excursion a success.

In the United States, as may be seen from the accompanying charts, the path of totality crosses the southern states from New Orleans, La., to Norfolk, Va. It is crossed by railroads at many points, and the great railroad centers of the various states, New Orleans, La., Mobile and Montgomery, Ala., Atlanta, Macon and Augusta, Ga., Columbia, S. C., and Raleigh, N. C., lie either within or near the course of the shadow. The investigations of the Weather Bureau (see POPULAR ASTRONOMY Nov. 1899) point to stations in Alabama and Georgia as the most likely to be free from

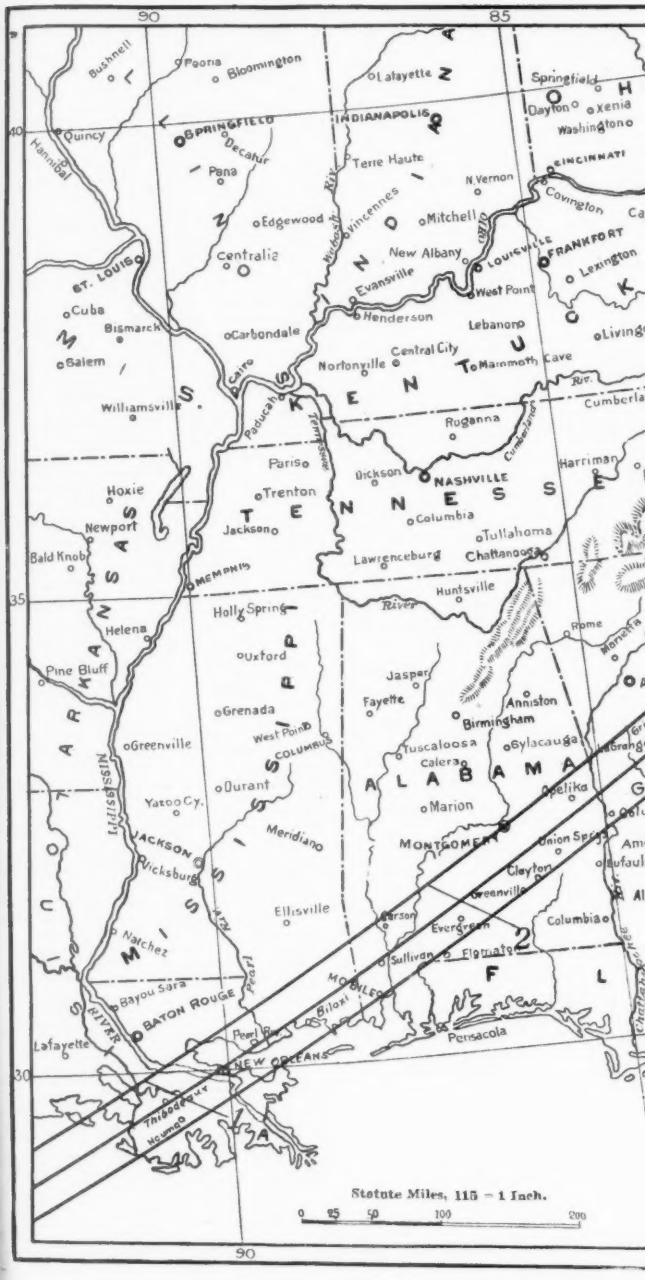
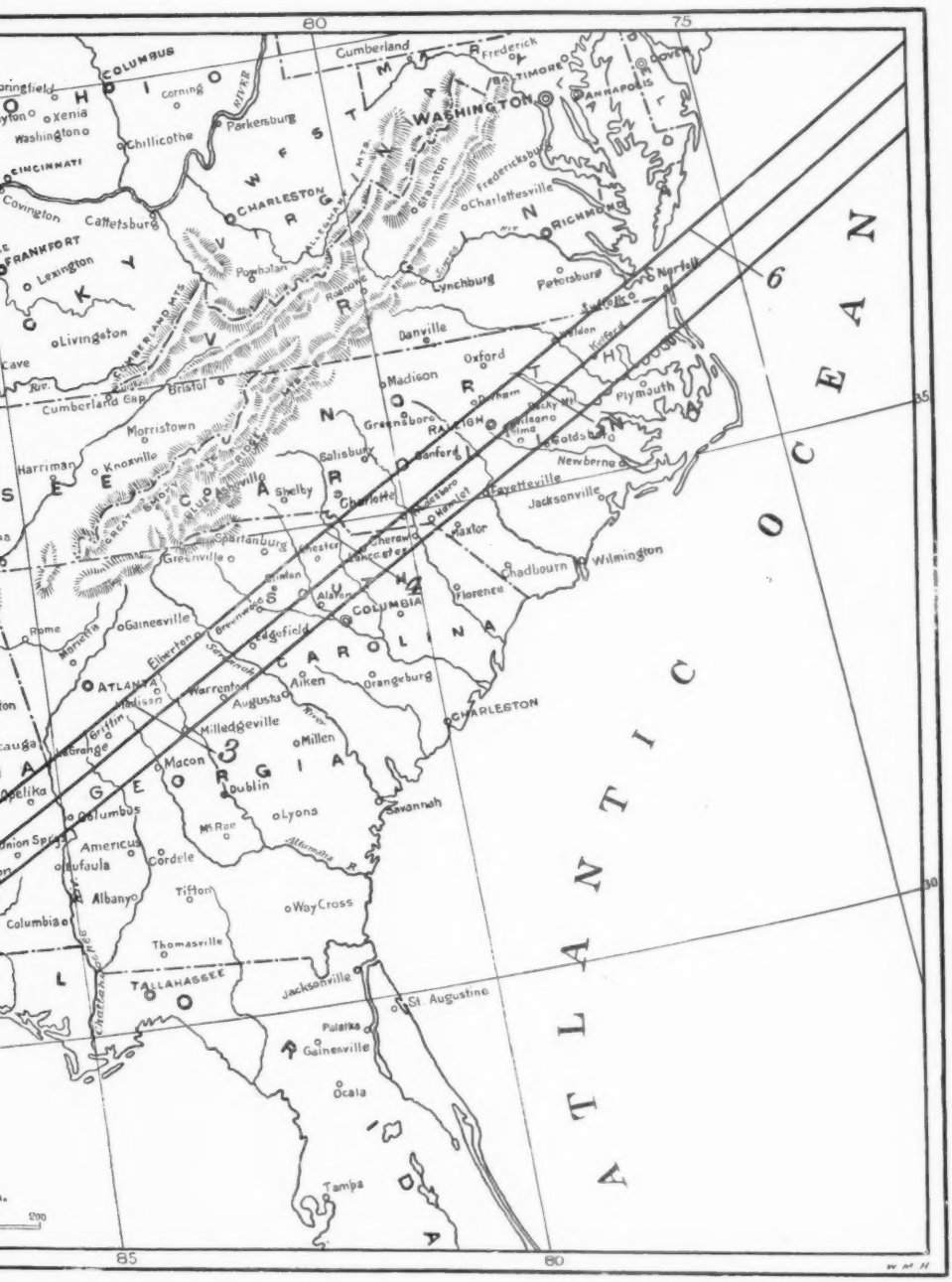


CHART II.—THE ECLIPSE TRACK

PLATE X



E TRACK AND THE OBSERVING STATIONS IN THE UNITED STATES.

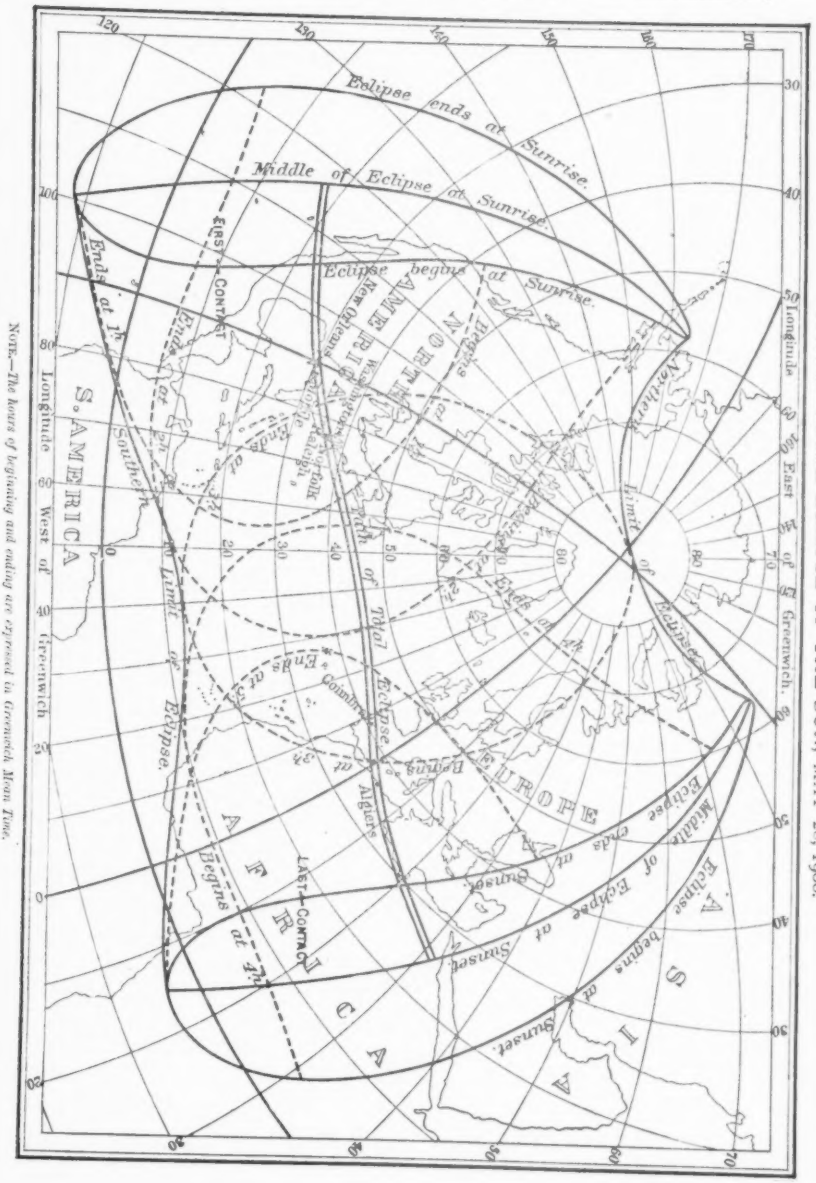


CHART I.—TOTAL ECLIPSE OF THE SUN, MAY 28, 1900.

NOTE.—*The hours of beginning and ending are expressed in Greenwich Mean Time.*

clouds, so that doubtless most scientific parties from a distance will endeavor to locate in those states. There will be, however, many local parties all along the line, who will witness the wonderful phenomena of the total eclipse and try to collect data for the scientific study of the mystery of the Sun's surroundings.

A few will go to Mexico, where the path of totality crosses four lines of railway, about 170 miles north of Zacatecas, 100 miles south of Saltillo, 100 miles south-east of Monterey and on the Texan border about 100 miles north-west of Matamoras. Here, however, the eclipse will occur early in the morning, totality coming between six and seven o'clock A. M., and lasting less than a minute.

At New Orleans the eclipse begins at 6:25 A. M., is total at $7^h\ 30^m$ and ends at ends at $8^h\ 43^m$ A. M. Totality lasts $1^m\ 12^s$. As the 6^h meridian from Greenwich passes through New Orleans, local and standard time there agree.

On the Atlantic coast, near Norfolk, Va., the eclipse will begin at $7^h\ 37^m$, will be total at $8^h\ 49^m$, totality lasting $1^m\ 40^s$, and will end at $10^h\ 11^m$ A. M., local time.

From these statements one can easily judge of the altitude of the Sun at the intermediate stations, and of the conditions under which the eclipse may be observed, barring bad weather.

Chart No. 1, accompanying this paper, shows that the eclipse will be partial over nearly the whole of North America, a little of South America, the whole of Europe, the northern part of Africa and a little of the western part of Asia. Observers who are unable to go to the path of the total eclipse, although missing the grand spectacle of the corona, will yet be able to witness the partial covering of the Sun by the dark Moon, and may contribute something useful to science by noting the exact moments of the beginning and end of the eclipse. It will be necessary for this that the latitude and longitude of the place of observation be carefully determined, and that the errors of the time pieces used be found within a quarter of a second. The time is telegraphed each day, from the U. S. Naval Observatory, over the Western Union telegraph lines, and on that day the signals will doubtless be more than usually correct. Observers may thus find the errors of their time pieces by carrying them to the nearest railway station and comparing them with the clock at Washington.

Chart No. 2 (reprinted from Professsr Bigelow's paper, POPULAR ASTRONOMY, Nov. 1899), shows the path of totality across the United States, and most of the stations along the path.

According to the larger map issued more recently by the U. S.

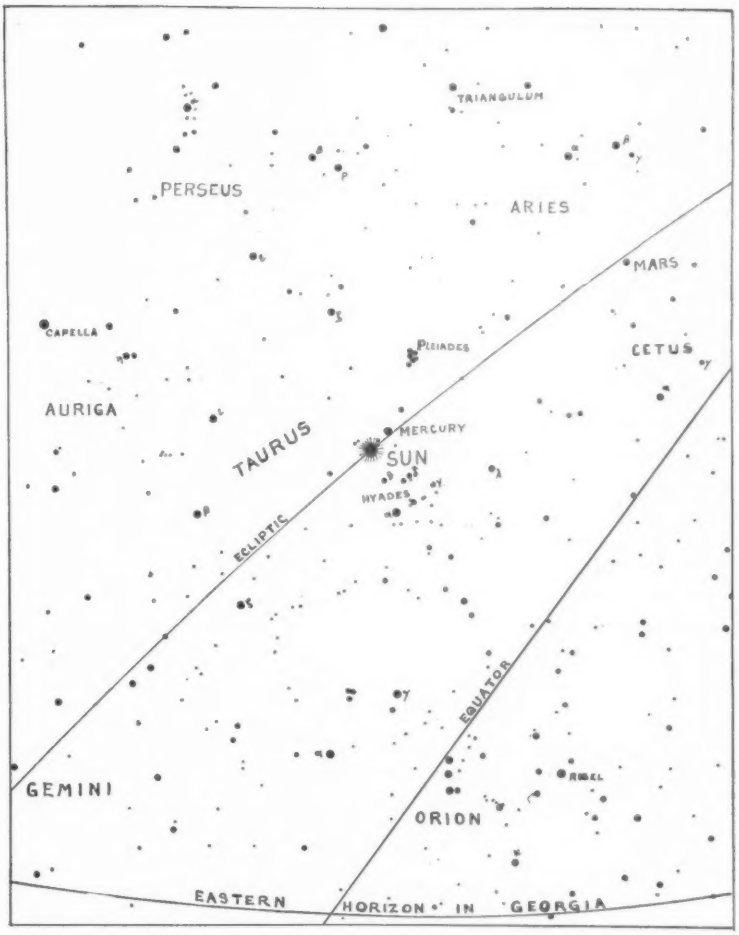


CHART III.—THE STARS IN THE VICINITY OF THE SUN, MAY 28, 1900.

Naval Observatory, this chart is not quite exact, the center line of the path of total eclipse being drawn approximately five miles too far south at New Orleans, and about the same distance too far north near Norfolk.

Chart No. 3 shows the position of the Sun among the stars at the time of the eclipse. The line at the bottom of the chart represents the eastern horizon as seen in Georgia, about the middle of

the path across the United States, longitude 83°, latitude 33° 30′, the Sun's altitude there being about 40° at the time of totality. The faintest stars given on the chart are of the fifth magnitude, but it is probable that these will not be visible to the naked eye. It is doubtful whether the darkness during this short totality will be sufficient to render anything fainter than the third magnitude visible. Mercury may be seen a little way above the Sun, and Mars also, well up toward the meridian. The Hyades and Pleiades, the nearest groups of stars to the Sun, may possibly be recognized, but are more likely to be overpowered by the brilliancy of the corona.

The eclipse supplement to the American Ephemeris, 1900, contains many admirable suggestions to observers of the eclipse under the headings: 1. Sketches of the corona with the naked eye. 2. The Moon's shadow bands. 3. Photographs of the corona. 4. Observations of the times of the contacts.

As the suggestions under the first two heads can be followed by many persons with the slightest of equipment, we give them here, taking issue with Professor W. H. Pickering (See page 225), on the usefulness of this kind of work. Good photographs of the corona will always have great scientific value, for only by these can the intricate details of the coronal structure be accurately depicted, and thus its laws of formation and change be studied. Photography, however, fails in some respects and needs to be supplemented by careful eye observations and drawings.

I.—SKETCHES OF THE CORONA WITH THE NAKED EYE.

The duration of totality will be short, varying from $1^m\ 12^s$ in the neighborhood of New Orleans to $1^m\ 40^s$ near Norfolk. Preliminary preparations therefore should be carefully made, and the necessary skill and quickness acquired by practice on artificial models. Those who expect to make a sketch of the corona unaided will have to confine their attention to sketching the outlines or to some other particular feature, otherwise there will result hasty and inaccurate work. Co-operation of groups of from two to five sketchers, as practiced in the last eclipse in India, 1898, is strongly commended by the successful drawings then made.

In any case, whether sketching singly or in co-operation with others, there should be prepared a diagram to form the basis of the drawing of the corona. A sheet of paper of convenient size, about 9 by 12 inches, should have drawn upon it a black disk 1¼ inches in diameter to represent the Moon, with straight lines radiating from the center at angles of 30°. The positions of the various parts of the corona, as seen projected against the sky,

are best referred to a vertical line obtained by mounting a plumb line so that it is seen hanging over the Moon's center. The diagram upon which the drawing is to be made is to be placed upon any convenient support, so that the line marked "Top" "Bottom" shall be in the plane of the plumb line, the top part corresponding to the top of the string.

Others might find it more easy to estimate the angular positions by dividing the diagram into four quadrants, as the actual position of the parts of the corona as seen in the sky will have to be estimated from the vertical plumb line and an imaginary horizontal line perpendicular to the plumb line.

For the benefit of those who may wish to try the co-operative plan of sketching, the following hints with but little modification are taken from the report of the British Astronomical Association on "Indian Eclipse, 1898."

"HINTS FOR MAKING DRAWINGS OF THE CORONA.

"1. The party should consist of at least five persons—four to sketch details of single quadrants, and one (the leader) to sketch rapidly the general features of the corona. The leader will then be able to correct and supplement the work of the quadrant sketchers, when producing the combined sketch. This must be done on the same day, immediately after the eclipse, in consultation with the whole party; and all the drawings should be photographed as soon as completed. The drawings themselves, even if faulty, should not be touched after completion.

"2. The party should practice together beforehand, each one sketching his own proper quadrant from a corona drawing suspended at the angular height of the Sun. The time of exposure of the drawing should be slightly less than the known duration of the eclipse. By rotating the drawing it may be made to serve for four sketches. The drawing must be well illuminated and clear, but must not be large. The Sun and Moon are small objects to the eye, and a large drawing would not give useful practice.

"3. Experience shows that Mr. Green's suggestion as to materials, white chalk on purplish blue paper, is an admirable one. For practicing, brown paper serves very well if blue paper is scarce.

"4. It is important always to practice on the same scale as the final sketch is to be made. It has been found that a silver half dollar ($1\frac{3}{16}$ inches in diameter), is a very convenient size for the black body of the Moon, and this may be always at hand. A circle, being drawn around the half dollar is bisected vertically and

horizontally, and the diameters are produced across the paper. The sketcher has a plumb line (a bunch of keys at the end of a string will do), with which he divides his model corona vertically as he looks up at it, and he guesses at the corresponding horizontal division. His quadrant thus fixed, he proceeds to sketch it. When the time is called the leader redraws all four quadrants in one combined sketch, and by comparison with the original, the habitual faults of the sketchers are detected, and in the course of a few practices will disappear.

"5. The position of any planet or high-magnitude star very near the Sun at the time of eclipse should be accurately ascertained, and its distance measured in terms of the Moon's diameter (taken as half a degree), as these facts when made familiar to the whole party will check the supposed direction and extent of any long streamers of the corona.

"6. On eclipse day the sketchers should avoid fatiguing their eyes by too much observation of the preceding partial eclipse, and should rest the eyes for the last five minutes before totality, absolutely. It would be well to close them for the last minute, and open them by a signal at totality. Attention should be paid to the extreme extent and to the color of the corona at the moment of beginning to draw, when the eye is at its freshest, and consequently is better able to observe these points than after gazing at the very bright inner parts of the corona."

It should not be inferred from the emphasis laid upon the number five that co-operation between two or three observers would not have an advantage over the method of making a sketch unaided.

II.—THE MOON'S SHADOW BANDS.

The Moon's shadow is bordered by diffraction bands of alternate light and shade, which are visible on any white background, and last about a minute before and after totality. At the eclipse expedition to the Caroline Islands in 1883 they were successfully observed, and the simple method adopted there is recommended. A white sheet, table spread, or another large piece of white cloth, is spread upon the ground and securely fastened, the edges lying north and south and east and west. The observer should be provided with a long rod, which he will lay upon the sheet either parallel or perpendicular to the shadow bands as they move rapidly across the sheet, in order to get their direction. A similar one should be used for the line succeeding totality, as the directions differ widely. Measure as accurately as practicable the direction of the two positions of the rods, using a compass or

other instrument in order to get their azimuth or bearing. A second observer, provided with a watch should try to count the number of bands per minute, and estimate carefully their distance apart in inches as they move across the white surface. In the report upon this phenomenon, in giving the direction of the rods with reference to the compass points, it should be stated whether they were placed parallel or perpendicular to the lines.

THE STUDY OF ASTRONOMY III.

W. W. PAYNE.

The brief articles before given in the January and Februry numbers of this publication have spoken of the views of some prominent school men about making elementary astronomy a part of the courses of study in the secondary schools, the methods of teaching astronomy where it is pursued; the marked changes that are now being introduced, sometimes known as the "inductive" or the laboratory methods; and the means of illustration so necessary in all ways of teaching astronomy. This last point is deemed so important that we promised to say more about it, and would have done so in our last number, but for the failure of engravers to reproduce the fine illustration of the Merope nebula which is given as the first plate in this number. In our last, we referred to the help which photographs of celestial objects gives in the study of details, which cannot be obtained so well in any other way. We printed some cuts of enlarged photographs of the Sun and Moon that our readers might get a fuller idea of the value of this means of illustration that could not be so well realized without them. We also referred to special ways of studying the details of sun-spots by the aid of the best drawings that have come to our notice. In that connection we should have said more about the study of the prominences and faculae by the aid of photographs obtained when the spectroscope is used in connection with the telescope. It is known, probably, to most of our readers, that very fine views of the prominences may be had in this way, and that both prominences and faculae can be photographed. The pictures that have been already obtained with some special forms of instruments are such as to give promise of useful results in the study of some important solar phenomena. There is certainly photographic power enough in the *H.* and *K.* region of the spectrum for much aid in pushing our knowledge further in regard to some conditions of solar activity.

We desire to call attention again to the work of Professor J. E. Keeler, Director of Lick Observatory, Mount Hamilton, California, in photographing some faint nebula by the aid of the Crossley reflector.

The picture which is our first plate, is the Merope nebula. This nebula fills a vast region of space around the star of the Pleiades, called Merope. The original negative was exposed four hours, on a fair night, but not one of the best. Professor Keeler says that the positive (from which our plate is made) does not show the small nebula, which is sometimes spoken of as Barnard's new Merope nebula, but that it does appear on the original negative. The positive was an enlargement of the original negative to four diameters, and our plate is the same size as the positive.

Our readers who are acquainted with the names and relative positions of the naked-eye stars in this group, will easily get the scale of the picture by noting the place of the apparently bright star above and to the right of Merope, in the midst of the nebula. That star is given in Young's cut, Fig. 229, p. 553 of the last edition of General Astronomy, as one of two faint stars nearly halfway between Merope and Electra. The other fainter star in the same direction from Merope, just on the edge of the plate, is another star in the little triangle shown in the cut above referred to. The space covered by this plate as represented on the cut would be a little more than one square inch; or about twenty minutes of arc each way, less than one-eighth of the area in the sky which the naked eye stars of the Pleiades seem to enclose.

If we now look at the beautiful plate in its details, we are able to get a glimpse of some of the wonders of this remarkable group of stars which have been a source of careful study by scholars in recent years.

The first thing noticed in regard to the central star, Merope, is the many rays of light that extend outward in all directions. We called attention to this in a brief paragraph in the March issue of this publication. As there said, we suppose the rays are due to the supports of the small mirror in the tube of the telescope. But the chief thing of interest is the structure of the nebulous matter surrounding Merope. It is at once seen that the exterior matter is not related to Merope as a center, in any such way as the nebulous masses appear to be in the great Andromeda nebula. There the nebulosity seems to fall into rings, more or less distinctly outlined, suggesting, possibly, rotary motion of the whole mass. We do not say that this ring formation gives more than a hint of the condition of the nebula in regard to motion. This

may or may not be the explanation of the rings that present so much of interest in detail, now so well seen in photographs of long exposure. In the Merope nebula the nebulous masses do not seem to be related. They are in streaks, straight and curved, in parallel lines that fade off gradually into faint streamers or dim, irregular patches soon lost to view, because they cannot be further followed by the power of the sensitive plate to catch the distant outlines, rather than the supposition that the end of their nebulosity has been reached. In this plate, and in other pictures of this nebula, the filiamentary structure of the main mass is very distinctly given. As we look at it thoughtfully we are reminded of the penumbra of great and active sun-spots, especially where the motion of the granular masses is somewhat evenly directed towards the umbra of the sun-spot. Can these striated forms in the nebulous masses mean motion? If so what kind of motion? The fact that some of them point one way and others another way, while the different systems of rays appear to be occupying the same space nearly is another most perplexing thing.

We mention a few of these interesting details to call attention to the great value of good photographs in the study of astronomy, and especially so if one is charged with the responsibility of giving instruction to students.

This must appear more strongly evident, when we remember that the largest telescope now in use will not present to the experienced observer so fine a view of the Merope nebula as that which is shown in Professor Keeler's fine negative, from which our cut by three or four intermediate processes has been obtained. Still more is it astonishing to us, when we remember that only a few years ago there was very lively discussion among prominent astronomers about the existence of any Merope nebula at all. In 1882 Professor Barnard of Yerkes Observatory, then at Nashville, Tenn , observed the nebula and made a drawing of it, which was published in the May number of the *Sidereal Messenger*. That drawing was then and is now correct for the brighter part of the nebula. But the things we now get by photography have so grandly surpassed all visual work, that it is no wonder that astronomers are enthusiastic over the new and later methods of study.

We very much wish to bring to the attention of all engaged in instruction in the elements of astronomy the great advantage of having good large scale photographs as a means of illustration. We have recently sent out about fifty of these pictures to those ordering them, and it is a pleasure to us to know that in all cases

the teachers receiving them have been very free in their words of commendation and satisfaction. Putting the price of these large astronomical pictures at 75 cents each, barely covers the cost, so the undertaking is certainly not renumerative to us.

We have just received from Dr. William Huggins and Lady Huggins of London, England, the finest volumes of spectroscopic work we have ever seen in print. It is their own work for years past, and it is most beautifully and perfectly executed, in representing spectra of celestial objects by the aid of photography. If we may get permission to reproduce some of these spectra in this publication, we will further tell our readers what may be done by photography on a large scale to illustrate the work of the spectroscope for the purpose of aid in instruction.

PHOTOGRAPHING THE CORONA.

W. B. FEATHERSTONE.

FOR POPULAR ASTRONOMY.

One of the greatest obstacles to obtaining satisfactory photographs of a solar eclipse is the uneven brightness of the corona. The parts near the Sun are so much brighter than the outlying streamers, that when the latter have been given sufficient exposure, the central portion of the plate has lost all detail from overtiming. The reverse is also true, so that a plate exposed for the inner corona and prominences shows but a trace of the outer corona and none of the fainter detail.

Some very good negatives have been made by the use of nonhalation plates, and by manipulating the plate during development, but it would, of course, be much better if the entire plate could be normally exposed at the start.

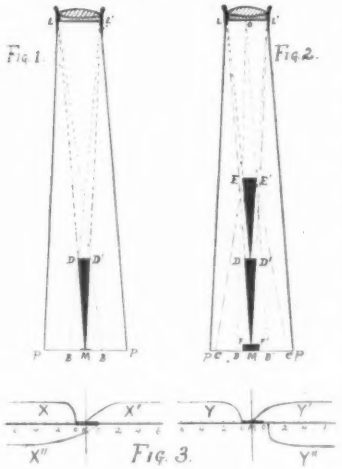
The following simple device comes very near making this possible, and can be used with a telescope or camera of any size.

Theoretically it does not provide for a perfectly even exposure, as does Mr. Burckhalter's apparatus, but it does so approximately, and this is all that can be accomplished with any device of the kind until the relative brightness of the corona at different distances from the Sun has been more accurately determined.

In the diagram LL' is the objective, PP' the sensitive plate and M the center of the Moon's image. The points BB' are distant two lunar radii from the Moon's limb.

Suppose a circular disc DD', be supported in the position shown,

and that its diameter be such that it just occults the lens when viewed from *M*.



Now gradually move the eye from *M* toward the edge of the field. The illumination increases as more of the lens becomes visible, until at *BB′* the plate is exposed to the full aperture. Outside of this point the corona is so faint that there is no danger of overexposure.

When the disc is in the position *DD′*, the prominences and the corona near the Moon's limb will be photographed by less than one-half of their normal light, while the plate at *BB′* and beyond, is exposed to the full aperture of the lens. (Curve *X′*, Fig. 3).

If *DD′* be moved toward *M*, the limb of the Moon will receive less illumination, while the normally-lighted area will extend inside of *BB′* and the light will be cut off less gradually (Curve *X′*, Fig. 3), while the reverse will occur if the disc be moved toward the lens. (Curve *X″*).

A second disc in the position *EE′*, Fig. 2, would cause the partially lighted region to extend into the outer corona (*CC′*), and would also modify the light-gradient for the inner corona, while the prominences would receive the same light as before. (Curve *Y″*, Fig. 3). If, however, it should be placed between *DD′* and the sensitive plate, it would serve to cut off still more light from the region of the Moon's limb, (Curve *Y*), and if it be desired to secure photographs before or after totality, a disc in the position *FF′* would effectually shield the plate from the intense light of the photosphere. (Curve *Y″*).

These discs may be mounted on a rod coincident with the optic axis of the camera and so arranged as to be readily adjusted from the outside. The rod should be supported at the end nearest the objective, so that its supports will not affect the image on the plate.

Instead of the round discs, a disc with serrated edges could, of course, be used, the size and shape of the notches corresponding to the estimated brightness of the corona at different distances

from the Sun, but in practice it will be found that the discs must be placed so close to the plate for the best results, that a stationary disc of any shape other than round will be sure to leave its silhouette in the picture.

Moreover, by using two or three circular discs, almost any gradation of light can be produced. The diameter of the discs and their relative positions will depend on the dimensions of the camera, but the diameter will usually be between $\frac{f}{40}$ and $\frac{f}{60}$ or 1½ to 2 times the diameter of the Moon's image, and the fundamental position *DD'* can be determined by placing the eye in the center of the field, when the disc should just occult the objective.

Another arrangement, described below, is to be preferred for several reasons. It not only limits the light from the brighter portion of the corona, but can also be made to act as a shutter, giving a graduated exposure to suit almost any condition.

The disc (*GG'*, Fig. 4), which is a trifle larger than the lens, is kept just outside of it, thus darkening the camera, until the plate is ready for exposure. It is then to be gradually moved to the position shown in the figure. As it recedes from the lens, first the outer corona, then the inner corona and prominences come into view, the relative amount of light from each depending upon the position of the disc and also upon the rate of speed with which it is moved to and from its position.

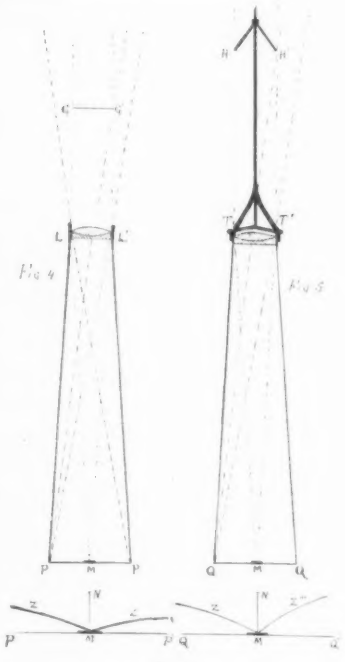


Fig. 6

The disc should be mounted centrally on a rod (*R*, Fig. 5), coincident with the optic axis of the objective, and this rod may be supported by a double tripod arranged to fit over the lens-cell or telescope tube, (*TT'*, Fig. 5). The occulting disc should then have the form of a conical shell (*HH'*) to admit of its fitting closely over the objective.

With the disc in the position *GG'*, Fig. 4, the relative amount of

light reaching any part of the sensitive plate, is roughly indicated by the curve *Z*, Fig. 6, where *PP'* represents the plate, *M* the Moon's image, and *MN* the height of the curve should all of the light reach the plate.

With the disc at *HH'*, the curve would be somewhat steeper (*Z'*), while it becomes much flatter as the disc is moved toward the lens (*Z''*). If a more rapid increase of light toward the outer corona is desired, the disc may be moved farther still from the lens and the light curve will approximate *Z'''*.

Other modifications of the light curve can be produced by moving the disc back and forth at a variable speed or by changing its position several times during the same exposure. The edges of the occulting disc may also be notched or serrated, but in that event it must either be revolved during exposure or kept quite close to the lens; otherwise its outline will appear on the negative.

For every short exposure the movements of the disc may be actuated by a spring and bulb release, arranged similar to the ordinary pneumatic shutter.

CHICAGO, ILL.,
March 20th, 1900.

MIGHT A COMET STRIKE THE EARTH.

REV. FREDERICK CAMPBELL.

FOR POPULAR ASTRONOMY.

What a comet is and whence it comes are questions still waiting to be answered. This seems the more wonderful when we consider that stars, which exhibit but mere points of light, are fairly understood, while a comet stretching its magnificent tail from zenith to horizon still presents an enigma. That the most conspicuous part of a comet is the less substantial part is accepted as true; the bright head, however, may enclose solid matter, as solid as the globe of a planet. And this suggests the query, what might happen if a comet should stike the earth:

Is a collision between a comet and the earth possible? There is no reason to doubt it. The planets move in concentric orbits about the Sun, their speed imparting to them a centrifugal force which keeps them away from the Sun and from each other, while the Sun's attraction on the other hand prevents their slipping away into the space and thus crossing each other's paths; hence

we are safe from collision with the planets. The Moon, too, is always kept at the safe distance of about 240,000 miles; hence she does not threaten our globe. But comets are strangers. They come from outside the solar system. They are here on a visit and do not know the ways of the family. And their path is very different from those followed by the planets. If it be in the same plane with the planets, instead of its being a great and nearly even circle about the Sun, it appears first as almost a straight line toward the Sun, bending more and more rapidly about that body, however, until the direction has been reversed; and now, following a similar path, the comet hastens away to more or less nearly the same region of the heavens from which it came, and so, having left the solar system, disappears from view. In making this journey the comet has crossed the orbits or paths of all the planets. It has not stopped to see whether the planets were due at the crossing points at the time when itself was coming. There are no signals to prevent both trains from trying to cross at the same moment, and if they do, something will happen. If the planet in question be the Earth, the Earth will in such a case be struck.

But if a comet struck the Earth, then what? Even if a comet's head be solid, it is not large, and there being twice as much water as land on our globe, the probabilities would be two to one that the comet would be lost in the bosom of the ocean. There being also vast stretches of uninhabited land, the probabilities greatly increase that the part of the Earth struck by the comet would be without population. Besides this, if the comet should strike where man dwells, the catastrophe would probably be only a local one, like that produced by an earthquake or a cyclone.

The next thing to give assurance is that the Earth is surrounded by a buffer in the form of an atmosphere, which reaches probably two hundred miles or more in every direction into space. If any foreign body be making for the Earth, it must first pass through this and be retarded by it. The heat generated by this concussion with our atmosphere consumes most of our meteors, so that they are turned into gas and seldom reach the ground in solid form. Even in the immensely cold spaces of the heavens, while still many millions of miles from the Sun, as they approach that central body, its slight heat vaporizes comets so as to generate what we call their "tails." This demonstrates how readily they are turned into thin gas, and suggests how the vastly greater heat developed by concussion with the Earth's atmosphere might speedily consume them in their very act of endeavoring to impinge upon the Earth.

Now, it is known that when a comet enters our solar system it is not making for a planet, but for the Sun. The Sun is the center of attraction for a visiting comet as well as for the various planets. A comet may indeed come from any possible direction, and thus not cross any of the orbits of the planets; but supposing it to cross the orbit of the Earth, as it might; that orbit is like a race track, about 560,000,000 miles around, which distance the Earth travels in one year. The Earth is flying over this course at the rate of 1,100 miles per minute. Let any one compute what are the probabilities of its being struck by a single body, moving with perhaps equal speed, which chances to cross its track. The Earth is but a speck of matter, while the nucleus of a comet is much smaller. Two boys throwing balls at each other might better expect that the balls would meet in the air; yet, what boys have the skill to bring this to pass? As Professor Newcomb says, firing a gun at random in the air might better be expected to bring down a bird than that it should be feared that a comet would ever strike the Earth.

The improbability of collision is the greater in view of the fact that comets, which make for the Sun, succeed in getting away again without a collision. We have had comets nearer the Sun than the nearest of all the planets, and yet they have harmlessly swung about that body and fled back into space. How much less, then, can they be expected to impinge upon the Earth. The Earth itself periodically draws many thousands of miles nearer the Sun, but as surely withdraws into space once more, and always unharmed. God has endowed the heavenly bodies with a momentum which, while it sometimes appears threatening, is really their safety. The nearer a comet approaches the Sun, it is hurried more and more rapidly so that it is less and less possible for the Earth's attraction so to deflect it from its course as to produce a collision. Had we no atmosphere to retard its movement, a cannon ball fired at a speed of seven miles a second would keep up a perpetual orbit about the Earth. Perrine's comet in 1896 was estimated to be approaching at the rate of 1,600,000 a day, which is about eighteen miles a second—more than twice as great as necessary to ensure that a cannon ball will not touch the ground. What probability, therefore, that the more swiftly coursing comet will strike the Earth?

The probability of collision with the comet's head is small, because the head itself is small. The tail presents a far larger degree of probability of collision. But so thin is the matter making up the tail that the faintest stars can be seen through a million

miles of it. This is evidently generated like steam from the comet's head. But there is more danger in a smoky day in the manufacturing districts of Chicago and Pittsburg than there is in passing through the tail of a comet. Of the lost Biela's comet, Professor Newcomb says: "It had seemingly vanished, not into thin air, but into something of a tenuity compared with which the thinnest air was as a solid millstone." He also declares that "the amount of matter really necessary to make the most splendid tail is so extremely small that a comet might lose it a hundred times over without becoming perceptibly smaller." As a matter of fact, the Earth has probably a number of times passed through a comet's tail, as in 1861, when the only visible effect was a singular phosphorescent mist.

Beyond and above all these considerations, we may well assure ourselves that, while we are under a reign of law, all laws are God's, and no law supersedes His sovereign will. No student of either the Bible or history can believe for one moment that the world's and man's existence in this world are without a plan. Nor can any careful observer believe for one moment that that plan has yet been fulfilled, so far as the human race is concerned. God will hold things in place till the Earth is redeemed. When the end comes, it will be within His power, if He so choose, to produce all its startling conditions by the simple effacing of a single law, namely, that of centrifugal force; this is what keeps all the worlds safely apart. If this law were suspended, gravity would have full sway, and all the worlds would rush together in a series of awful concussions which would literally fulfill the Word which says, "The heavens shall pass away with a great noise, and the elements shall melt with fervent heat; the Earth also, and the works that are therein shall be burned up." Happy are we if, in the midst of all the possibilities and certainties of the universe in which we dwell, we can say, "Nevertheless, we, according to His promise, look for new heavens and a new Earth, wherein dwelleth righteousness."

BROOKLYN, N. Y., 428½ Clinton Street.

THE MOON HOAX.

S. A. MITCHELL.

FOR POPULAR ASTRONOMY.

Throughout all ages of the world's history, there has been a tendency in the human mind to grasp after the new, the sensational and the mysterious; and to foster this inclination, there

have always been plenty of men ready and willing to devote their time to the making of so-called new and wonderful discoveries.

Astronomy, the most ancient of all the sciences, has been singularly free from attempts to pander to this craving on the part of man. The human mind, as a rule, has regarded reverently the discoveries in astronomy, but some instances of sensationalism have crept even into this grand old science.

While looking through the Struve library, which was obtained by Columbia University not long since, I ran across a pamphlet which is thoroughly interesting, although the matter contained is extremely surprising. This is the celebrated "Moon Hoax." This work obtained a great notoriety about the middle of the century, and in the hope that it may still be interesting to astronomers, these few pages are written.

Early telescopic observations of the moon were conducted with the confident expectation that the moon would be found to be an inhabited world, and that much would soon be learned of the manners and appearance of the Lunarians. With each increase of telescopic power a new examination was made, and it was only when the elder Herschel's great reflector failed to show any inhabitants on the face of the moon, that men began to look in doubt and think that perhaps the examination was hopeless. Herschel, himself, seemed to be of the opinion that the moon was inhabited, for, after describing the relations, physical and seasonal, that prevailed on the surface of the moon, he adds: "There only seems wanting, in order to complete the analogy, that it should be inhabited like our earth."

When Sir John Herschel carried his giant reflector to the Cape of Good Hope, the hope was renewed that he might be able to tell us something about the inhabitants of the moon. In fact, so confidently was this hope entertained, that when the "Moon Hoax" appeared about this time, purporting to be "*Great Astronomical Discoveries*, lately made by Sir John Herschel, LL. D., F. R. S., &c, at the Cape of Good Hope," there were many people who took every word of these wonderful discoveries in good faith, and were firmly convinced that the moon was inhabited.

The full title of this extraordinary little pamphlet is: "The Moon Hoax; or, The Discovery that the Moon has a Vast Population of Human Beings, by Richard Adams Locke." New York, 1859. The publisher tells us that it was first published in the "New York Sun" in August and September 1835, and that the interest in the discovery was so intense that the circulation of the

paper augmented five fold, and these articles, in fact, were the means of giving the journal a permanent footing as a daily newspaper. "Nor did this multiplied circulation of the paper satisfy the public appetite. The proprietors of the journal had an edition of 60,000 published in pamphlet form, which was sold off in less than a month."

It seems best to let this unique little book tell its story as nearly as possible in its own language. The author, Locke, tells us that he is "indebted to Dr. Andrew Grant for the almost exclusive information concerning the facts." Dr. Grant was the "pupil of the elder, and for several years past, the inseparable coadjutor of the younger Herschel, the amanuensis of the latter at the Cape of Good Hope, and the indefatigable superintendant of his telescope during the whole period of its construction and operation."

The story is told, in part, as follows:

"We are assured that when the immortal philosopher to whom mankind is indebted for the thrilling wonders now first made known, had at length adjusted his new and stupendous apparatus with a certainty of success, he solemnly paused several hours before he commenced his observations, that he might prepare his own mind for discoveries which he knew would fill the minds of myriads of his fellow-men with astonishment, and secure his name a bright, if not transcendant conjunction with that of his venerable father, to all posterity. And well might he pause! From the hour the first human pair opened their eyes to the glories of the blue firmament above them, there has been no accession to human knowledge at all comparable in sublime interest to that which he has been the honored agent in supplying. Well might he pause! He was about to crown himself with a diadem of knowledge which would give him a conscious pre-eminence above every individual of his species who then lived, or had lived in the generations that are passed away. He paused ere he broke the seal of the casket which contained it. To render our enthusiasm intelligible, we will state at once that by means of a telescope of vast dimensions, and an entirely new principle, the younger Herschel, at his Observatory in the Southern Hemisphere has already made the most extraordinary discoveries in every planet of our solar system; has discovered planets in other solar systems; has obtained a distinct view of objects in the moon, fully equal to that which the unaided eye commands of terrestrial objects at a distance of a hundred yards; and has affirmatively settled the question whether this satellite be inhabited.

The elder Herschel, several years before his death, conceived it

practicable to construct an improved series of parabolic and spherical reflectors, which, unite all the meritorious points in the Gregerian and Newtonian instruments, with the highly interesting achromatic discovery of Dollond. His plan evinced the most profound research in optical science, and the most dextrous ingenuity in mechanical contrivance; but accumulating infirmaties, and eventually death, prevented its experimental application. His son, Sir John Herschel, was so fully convinced of the value of the theory, that he determined upon testing it at whatever cost. Within two years of his father's death he completed his new apparatus, and adapted it to his father's telescope. He found that the magnifying power of 6,000 times, when applied to the moon, which was the severest criterion that could be accepted, produced, under these new reflectors a focal object of exquisite distinctness, free from every achromatic obscurity, and containing the highest degree of light which the great speculum could collect from that luminary. Yet the advance he had made in the knowledge of this planet, though magnificent and sublime, was thus but partial and unsatisfactory. A law of nature, and the finitude of human skill, seemed united in inflexible opposition to any further improvement in telescopic science, as applicable to the known planets and satellites of the solar system, for unless the sun could be prevailed upon to extend a more liberal allowance of light to these bodies, and they be induced to transfer it for the generous gratification of our curiosity, what adequate substitute could be obtained? Telescopes do not create light, they cannot even transmit unimpaired that which they receive. That anything further could be derived from human skill in the construction of instruments, the labors of his illustrious predecessors, and his own, left the son of Herschel no reason to hope.

The limits of discovery in the planetary bodies, and in this one especially, thus seemed to be immutably fixed. But about three years ago, in the course of a conversational discussion with Sir David Brewster on the invincible enemy of powerful magnifiers, the paucity of light, Sir John diffidently inquired whether it would not be possible to effect a *transfusion of artificial light through the focal object of vision!* Sir David, somewhat startled at the originality of the idea, paused awhile, and then hesitatingly referred to the refrangibility of rays, and the angle of incidence. Sir John, grown more confident, adduced the example of the Newtonian reflector, in which the refrangibility was corrected by the second speculum, and the angle of incidence restored by the third. "And," continued he, "why cannot the illuminated

microscope, say the hydro-oxygen, be applied to render distinct, and, if necessary, even to magnify the focal object?" Sir David sprang from his chair in an ecstacy of conviction, and leaping half-way to the ceiling exclaimed, "Thou art the man!" Each philosopher anticipated the other in presenting the prompt illustration that, if the rays of the hydro-oxygen microscope passed through a drop of water containing the larvæ of a gnat and other objects invisible to the naked eye, rendered them not only keenly but firmly magnified to dimensions of many feet; so could the same artificial light, passed through the faintest focal image of a telescope, both distinctify [to coin a new word for an extraordinary occasion], and magnify its feeblest members. The only desideratum was a recipient for the focal image which should transfer it, without refranging it, to the surface on which it was to be viewed under the revivifying effect of the microscopic reflectors. In the various experiments made in the few following weeks, the co-operative philosophers decided that a medium of the purest plate glass was the most eligible they could discover. It answered perfectly with a telescope which magnified 100 times, and a microscope of about thrice that power.

Sir John Herschel then conceived the stupendous fabric of his present telescope. The power of his father's instrument would still leave him distant from his favorite planet nearly forty miles, and he resolved to attempt a greater magnifier. Sir John had submitted his plans and calculations in adaptation to an object glass of twenty-four feet in diameter; just six times the size of his venerable father's. For casting this ponderous mass, he selected the large glass house of Messrs. Hartly & Grant (the brother of our invaluable friend, Dr. Grant), at Dumbarton. The material chosen was an amalgamation of two parts of the best crown with one of flint glass, the use of which, in separate lenses, constituted the great achromatic discovery of Dollond. It had been found, however, by accurate experiments, that the amalgam would as completely triumph over every impediment, both from refrangibility and discoloration, as the separate lenses. Five furnaces of metal, carefully collected from productions of the manufactory, in both kinds of glass, and known to be respectively of nearly perfect homogeneous quality, were united by one grand conductor to the mould; and on the third of January, 1833, the first cast was effected. After cooling eight days the mould was opened, and the glass found to be greatly flawed within eighteen inches of the center. Notwithstanding this failure, a new glass was more carefully cast on the twenty-seventh of the same month,

which on being opened during the first week in February, was found to be immaculately perfect, with the exception of two slight flaws so near the line of its circumference that they could be covered by the copper ring in which it was desired to be enclosed.

The weight of this prodigious lens was 14,826 pounds, or nearly seven tons, after being polished; and its estimated magnifying power was 42,000 times. It was therefore presumed to represent objects on our lunar surface a little more than eighteen inches in diameter, provided its focal image of them could be rendered distinct by the transfusion of artificial light. It was not, however, upon the mere illuminating power of the hydro-oxygen microscope, as applied to the focal pictures of this lens, that the younger Herschel depended for the realization of his ambitious theories and hopes. He calculated largely upon the almost illimitable applicability of this instrument as a second magnifier, which would supersede the use and infinitely transcend the powers of the highest magnifiers in reflecting telescopes.

So sanguinely did he calculate upon the advantages of this splendid alliance, that he expressed confidence in his ultimate ability to study even the entomology of the moon in case she contained insects upon her surface!

Having witnessed the completion of this great lens, his next care was to construct a suitable microscope, and the mechanical frame-work for the horizontal and vertical action of the whole. His plans in every branch of his undertaking having been intensely studied, even to their minutest details, were easily and rapidly executed. He awaited only the appointed period at which he was to convey his magnificent apparatus to its destination, the Cape of Good Hope.

The ground plan for the mounting is in some respects similar to that of the Herschel telescope in England. The observatory is a wooden building fifty feet square and as many high, with a flat roof. This is brought by means of parallel circles of railroad iron to the required position with respect to the lens. * * * * The lens, which is inclosed in a frame of wood, and braced to its corners by bars of copper, is suspended upon an axis between two pillars which are nearly as high as those which supported the celebrated quadrant of Uleg Beg, being one hundred and fifty feet. Between the pillars is a double capstan for hoisting the lens from its horizontal line to the height required by its focal distance when turned to the meridian, and for elevating it to any intermediate degree of altitude that may be needed. Having no tube, it is connected with the observatory by two horizontal levers, which pass

beneath the floor of the building from the circular base of the pillars. * * * * The field of view, therefore, whether exhibited on the floor or on the wall of the apartment, has a diameter of nearly fifty feet, and being circular it has an area of 1875 feet.

It was about half-past nine on the night of January 10th, the moon having advanced within four days of her mean libration, that the astronomer adjusted his instruments for the inspection of her eastern limb. The whole immense power of the telescope was applied, and to its focal image about one-half the power of the microscope. We gazed upon the shores of the Mare Nubium of Riccoli; but why he so termed it, unless in ridicule of Cleomedes, I know not, for fairer shores never angels coasted on a tour of pleasure. A beach of brilliant white sand, girt with wild castellated rocks, apparently of green marble, varied by chasms occuring every two or three hundred feet, with grotesque blocks of chalk or gypsum, and feathered or festooned at the summit with the clustering foliage of unknown trees, moved along the bright wall of our apartment until we were speechless with admiration. The water, wherever we had a view of it, was nearly as blue as that of the deep ocean, and broke in large white billows upon the strand. Our panting hopes were soon to be blest with specimens of conscious existence, for, beneath the shade of the luxurious trees we beheld our first animal. It was of a bluish color, about the size of a goat, with a head and beard like him, and a single horn, slightly inclined forward from the perpendicular. The female was destitute of the horn and beard, but had a much longer tail. It was gregarious and chiefly abounded on the acclivitous glades of the woods. In elegance of symmetry it rivaled the antelope, and like him it seemed an agile sprightly creature, running with great speed, and springing from the green turf with all the unaccountable antics of a young lamb or kitten. This beautiful animal afforded us most excellent amusement. Frequently, when attempting to put our fingers upon its beard, it would suddenly bound away into oblivion, as if conscious of our earthly impudence; but then others would appear, whom we could not prevent nibbling the herbage, say or do what we would to them.

We soon came across a beautiful valley, and found a large branching river, abounding with lovely islands, and water birds of numerous kinds. A species of gray pelican was the most numerous, but a black and white crane, with unreasonably long legs and bill, was also quite common. Near the upper extremity of one of these islands we obtained a glimpse of a strange amphibious creature, which rolled with great velocity across the pebbly beach,

and was lost sight of in the strong current which set off from this angle of the island. We were compelled, however, to leave this prolific valley unexplored, on account of clouds which were evidently accumulating in the lunar atmosphere, our own being perfectly translucent. But this was of itself an interesting discovery, for more distant observers had questioned or denied the existence of any humid atmosphere in this planet. The moon being low in her descent, Dr. Herschel decided that it was useless to carry our labors further, especially as our minds were actually tired with the excitement of the high enjoyment we had partaken.

Our next night of observation was a beautiful clear night, and we set to our work filled with expectancy. While gazing at the landscape in the Valley of the Unicorn we were thrilled with astonishment to perceive four successive flocks of large-winged creatures, wholly unlike any kind of birds, slowly descend from the cliffs and alight upon the plain. These were first noticed by Dr. Herschel, who exclaimed, "Now, gentlemen, my theories against your proofs. We have here something worth looking at. I was confident that if ever we found beings in human shape, it would be in this longitude, and that they would be provided by their Creator with some extraordinary powers of locomotion." Introducing a lens of higher power, we perceived that certainly they *were* like human beings, for their wings had now disappeared and their attitude in walking was both erect and dignified. By our lens, we could bring them to an apparent proximity of eighty yards. They averaged four feet in height, were covered, except on the face, with short and glossy copper-colored hair, and had wings of thin membrane, without hair, lying snugly upon their backs, from the top of the shoulders to the calves of the legs. The face, which was of a yellowish flesh color, was a slight improvement upon that of the large orang outang, being more open and intelligent in its expression, and having a much greater expansion of forehead. The mouth, however, was very prominent, though somewhat relieved by a thick black beard upon the lower jaw, and by lips far more human than any species of the simia genus. In general symmetry of body and limbs, they were far superior to the orang outang. The hair on the head was a darker color than that of the body, closely curled, but apparently not woolly, and arranged in curious semi-circles over the temples of the forehead. Their feet could be seen as they were alternately lifted in walking, but, from what we could see of them in so transient a view, they appeared thin and very protuberant at the heel. Whilst passing across the canvas, and whenever we after-

wards saw them, these creatures were evidently engaged in conversation, their gesticulation, more particularly the varied action of their hands and arms, appeared impassioned and emphatic.

Turning from these creatures, we surveyed the shores of the Mare Serenetatis, which is nearly square, being about 330 miles in length and width. This sea has one most extraordinary peculiarity, which is a perfectly straight range of hills, certainly not more than five miles wide. This singular ridge is perfectly *sui generis*, being altogether unlike any mountain chain either on this earth or on the moon itself. Our lens brought it within the small distance of 800 yards. Nothing we had hitherto seen more highly excited our astonishment. Believe it, or believe it not, it was one entire crystallization! Its edge through its whole length of 340 miles is an angle of solid quartz crystal, brilliant as a piece of Derbyshire spar just brought from a mine, and containing scarcely a fracture or a chasm from end to end!

But our eyes were still further gladdened by the sight of more inhabitants. These seemed to be of the same species as our winged friends, and having adjusted the instrument for a more minute examination, we found that nearly all the individuals of several large groups we saw were of a larger stature than the former specimens, less dark in color, and in every respect an improved variety of the race. They were chiefly engaged in eating a large yellow fruit like a gourd, sections of which they divided with their fingers, and ate with rather uncouth voracity, throwing away the rind. They seemed eminently happy, and even polite, for we saw, in many instances, individuals sitting nearest these piles of fruit select the largest and brightest specimens and throw them archwise to some opposite friend or associate who had extracted the nutriment from those scattered around him, and which were frequently not a few. While thus engaged in their rural banquets, or in social converse, they were always seated with their knees flat upon the turf, and their feet brought evenly together in the shape of a triangle, and for some mysterious reason or other, this figure seemed to be an especial favorite among them; for we found that every group or social circle arranged itself in this shape before it dispersed, which was generally done at the signal of an individual who stepped into the center and brought his hands over his head in an acute angle. At this signal each member of the company extended his arms forward so as to form an acute horizontal angle with the extremity of the fingers. But this was not the only proof that they were creatures of order and subordination. * * * * But although evidently the highest order of

animals in this lovely valley, they were not its only occupants. The most attractive of the quadrupeds was a tall white stag, with lofty spreading antlers, black as ebony. We several times saw this beautiful creature trot up to the parties of semi-human beings, and brouse the herbage close beside them, without the least manifestation of fear on its part or notice on theirs. This universal state of amity among all classes of lunar creatures, and the apparent absence of every carniverous or ferocious species, gave us the most refined pleasure and doubly endeared to us this lovely nocturnal companion of our larger, but less favored world.

During the month of March we were able to get some more observations, and while looking at the noble valleys at the foot of Atlas we found a very superior species of Lunarian. In stature they did not exceed those last described, but they were of infinitely greater personal beauty, and appeared in our eyes scarcely less lovely than the general representation of angels by the more imaginative schools of painters. Their social economy seemed to be regulated by laws and ceremonies like the former beings seen, but their works of art were more numerous, and displayed a proficiency of skill quite incredible to all except actual observers. I shall therefore let the first detailed account of them appear in Dr. Herschel's authenticated natural history of this planet."

This is the "Moon Hoax," with its flowery descriptions of planet and animal life on our satellite.

How much of these "discoveries" did the people back in the thirties and forties believe? This we can guage by quoting a few of the press criticisms as given in the contemporary daily New York papers:

"No article, we believe, has appeared for years that will command so general a perusal and publication."—*Daily Advertiser.*

"It appears to carry intrinsic evidence of being an authentic document."—*Mercantile Advertiser.*

"It is quite proper that the *Sun* should be the means of shedding so much light on the *Moon* "—*N. Y. Evening Post.*

"The account of the wonderful discoveries in the moon are all probable and plausible, and have an air of intense versimilitude." —*N. Y. Times.*

This hoax was published in serial form in the *Sun* from August 25 to 31st, inclusive.* About the same time there appeared three French translations at Paris, one at Bordeaux, and Italian trans-

* The writer has seen the original copies of the "Sun" containing the "Great Astronomical Discoveries," &c.

lations at Parma, Palermo and Milan. A "second edition" of this pamphlet was published in London, 12mo., 1836.

The authorship of this article was attributed to Richard Adams Locke, at that time the editor of the *New York Sun*. But besides the great fluency of style and the masterful command of the English language shown by the "Moon Hoax," there is evinced in this article so accurate a knowledge of astronomical facts, even to the most scientific details, that it is evident none but an astronomer of more than ordinary ability could have written it. This Locke certainly was not. After severing his connection with the *Sun*, Locke edited the *New Era*, and soon after, there appeared in this periodical another hoax, "The Lost Manuscript of Mungo Park," also by Locke. This, however, while showing the same peculiarities in style as the "Moon Hoax," lacked greatly the bold and daring conception in the plot of the latter, and as a result secured very little notoriety. It would seem, therefore, that there had been some bolder and more learned spirit than Locke's which had conceived the plot of the "Moon Hoax," and supplied the editor of the *Sun* with the astronomical facts necessary for the construction of the article. Dr. Andrew Grant, alluded to in the text, seems to be as evanescent as the lunarians. But who, then, with such an idea and the knowledge for its development, would be content to give it to another and remain himself unknown? And what could be his reason for so doing? We seem to find this man in the person of M. J. N. Nicollet, a noted French astronomer, who, for some unknown cause, had been compelled to leave France and seek refuge in America. This astronomer, in connection with MM. Brousseaud and Bouvard, was the author of an important memoir, "Sur la Libration de la Lune;" and in Amer. Phil. Soc. Trans., Vol. VIII, 1842, pp. 306-310, we have a work of his, published under the title of "Observations Made at Several Places in the United States." With Nicollet as the author, we find an explanation of the precise astronomical knowledge shown in our article, and especially the frequent use of the term "libration" in his descriptions of the moon. But we do not see any apparent reason why Nicollet should be willing to allow another to appear as the author of any of his articles. There are, however, a couple of stories about him which perhaps will throw a little light on this question. One story is that Nicollet was a fugitive from Paris, taking some money that did not belong to him, and that his "Moon Hoax" was published in America, simply for the purpose of earning him some money, and being a Frenchman, he obtained Locke's help to put the story into pol-

ished English. Another, and a more probable story is, that by his hoax, Nicollet endeavored to entrap his enemy, the astronomer, Arago, in which he succeeded, Arago circulating the wonderful story through Paris until Nicollet, in a letter to M. Bouvard explained the hoax. With this for a motive, it can be easily seen that Nicollet would not care to have the hoax appear over his signature, or allow any hint as to his identity to appear in the article.

It thus appears almost an assured fact that Nicollet, through the medium of Locke, was the real author of the "Moon Hoax," and that it is to him we are indebted for these very interesting "astronomical discoveries."

COLUMBIA UNIVERSITY,
March 15, 1900.

NON-EUCLIDEAN GEOMETRY.

GEORGE BRUCE HALSTED.

FOR POPULAR ASTRONOMY.

In writing of "The Wonderful Century," Alfred Russel Wallace says of all time before the seventeenth century: "Then, going backward, we can find nothing of the first rank except Euclid's wonderful system of geometry, perhaps the most remarkable mental product of the earliest civilizations."

But of late all men of science and intelligent teachers have been hearing more and more of non-Euclidean geometry, and are naturally anxious to know how these new doctrines are related to the traditional geometry which they were taught and perhaps now are teaching.

The new departure is absolutely epoch-making, but fortunately it has intensified admiration for that imperishable model, already in dim antiquity a classic, the immortal *Elements* of Euclid.

But without assumptions nothing can be proved, and Euclid stated his assumptions with the most painstaking candor. He would have smiled at the suggestion that he could ever claim for his conclusions any other truth than perfect deduction from assumed hypotheses.

And so his system is forever safe. Should each one of his axioms turn out to be inconsistent with external reality; should each of his fundamental assumptions be replaced in our final explanation of the space in which we live and move; in reference to our space, should all his theorems be shown to be only

approximations; yet his work will remain a perfect piece of pure mathematics, the exact, eternal geometry of Euclidean space.

For two thousand years no one ever doubted the truth of any one of this set of axioms, far the most influential in the intellectual history of the world, put together by Euclid in Egypt, but really owing nothing to the Egyptian race, nothing to the boasted lore of Egypt's priests.

The Papyrus of the Rhind, belonging to the British Museum, but given to the world by the erudition of a German Egyptologist, Eisenlohr, and a German historian of mathematics, M. Cantor, gives us more knowledge of the state of mathematics in ancient Egypt than all else previously accessible to the modern world. Its whole testimony confirms with overwhelming force the position that geometry as a science, strict and self-conscious deductive reasoning, was created by the subtle intellect of the same race whose bloom in art still overawes us in the Venus of Milo, the Apollo Belvidere, the Laocoön.

But though for twenty centuries the truth of the axioms of the Greek geometer remained unquestioned, there was one of them of which the axiomatic character was doubted even from far antiquity. Elementary geometry was for two thousand years as stationary, as fixed, as peculiarly Greek as the Parthenon. But among Euclid's assumptions is one differing from the others in prolixity, whose place fluctuates in the manuscripts.

Peyrard, on the authority of the Vatican MS., puts it among the postulates, and it is often called the parallel-postulate. Heiberg, whose edition of the Greek text is the latest and best (Leipzig, 1883-1888), gives it as the fifth postulate.

James Williamson, who published the closest translation of Euclid we have in English, indicating, by the use of italics, the words not in the original, gives this assumption as eleventh among the Common Notions.

Bolyai speaks of it as Euclid's Axiom XI.

Todhunter has it as twelfth of the Axioms.

Clavius (1574) gives it as Axiom 13.

The Harpur Euclid separates it by forty-eight pages from the other axioms.

It is not used in the first twenty-eight propositions of Euclid. Moreover, when at length used, it appears as the inverse of a proposition already demonstrated, the seventeenth, and is only needed to prove the inverse of another proposition already demonstrated, the twenty-seventh.

Geminos of Rhodes (about 70 B. C.) speaks of it as needing

proof. The astronomer Ptolemy (A. D. 87-165) tried his hand at proving it.

The great Lambert expressly says that Proklos demanded a proof of this assumption because when inverted it is demonstrable.

The Arab Nasir-Eddin (1201-1274) tried to demonstrate it.

No one had a doubt of the necessary external reality and exact applicability of the assumption. Until the present century the Euclidean geometry was supposed to be the only possible form of space-science; that is, the space analyzed in Euclid's axioms was supposed to be the only non contradictory sort of space.

But could not this assumption be deduced from the other assumptions and the twenty-eight propositions already proved by Euclid without it? Euclid demonstrated things more axiomatic by far. He proves what every dog knows, that any two sides of a triangle are together greater than the third.

Yet after he has finished his demonstration, that straight lines making with a transversal equal alternate angles are parallel, in order to prove the inverse, that parallels cut by a transversal make equal alternate angles, he brings in the unwieldy assumption thus translated by Williamson (Oxford, 1781):

"II. And if a straight line meeting two straight lines make those angles which are inward and upon the same side of it less than two right angles, the two straight lines being produced indefinitely will meet each other on the side where the angles are less than two right angles."

As Staeckel says, "it requires a certain courage to declare such a requirement, alongside the other exceedingly simple assumptions and postulates."

In the brilliant new light given by Bolyai and Lobachevski, we now see that Euclid understood the crucial character of the question of parallels.

There are now for us no better proofs of the depth and systematic coherence of Euclid's masterpiece than the very things which, their cause unappreciated, seemed the most noticeable blots on his work.

Sir Henry Savile, in his Praelectiones on Euclid, Oxford, 1621, p. 140, says: "In pulcherrimo Geometriae corpore duo sunt naevi, duae labes . . . " etc., and these two blemishes are the theory of parallels and the doctrine of proportion; the very points in the Elements which now arouse our wondering admiration.

But down to our very nineteenth century an ever renewing

stream of mathematicians tried to wash away the first of these supposed stains from the most beauteous body of Geometry.

The attempts may be divided into three classes: First, those in which is taken a new definition of parallels. Second, those in which is taken a new axiom different from Euclid's. Third, the largest and most desperate class of attempts, namely, those which strive to deduce the theory of parallels from reasonings about the nature of the straight line and plane angle. Hundreds of mathematicians tried at this. All failed. That eminent man, Legendre, was trying at this, and continually failing at it, throughout his very long life. Thus the experience of two thousand years went to show that here some assumption was indispensable. Every species of effort was made to avoid or elude it, but without success. From a letter of Gauss we see that in 1799 he was still trying to prove that Euclid's is the only non-contradictory system of geometry, and that it is the system regnant in the external space of our physical experience. The first is false; the second can never be proven.

Yet even in 1831 the acute logician, De Morgan, accepted and reproduced a wholly fallacious proof of Euclid's assumption, recently republished, Chicago, 1898.

A like pseudo-proof published in *Crelle's Journal* (1834) deceived even our well known Professor W. W. Johnson, who translated and published it in the *Analyst* (Vol. III, 1876, p. 103), saying, "this demonstration seems to have been generally overlooked by writers of geometrical text-books, though apparently exactly what was needed to put the theory upon a perfectly sound basis."

The most interesting and perhaps the most extended of such attempted proofs was by the Italian Jesuit Saccheri, born the fifth of September, 1667, who joined the Society of Jesus at Genoa, on the twenty-fourth of March, 1685. He became teacher of grammar in the Jesuit "Collegio di Brera," where the teacher of mathematics was Tommaso Ceva, a brother of the well known mathematician, Giovanni Ceva (1648-1737), who published in 1678 at Milan a work containing the theorem now known by his name.

Saccheri was in close scientific communion with both brothers and received his inspiration from them. He used Ceva's ingenious methods in his first published work, 1693, solutions of six geometric problems proposed by Count Roger Ventimiglia. His attempt at proving the parallel-postulate is his last work, "Euclid vindicated from every fleck," which received the "Im-

primatur" of the Inquisition the thirteenth of July, 1733, that of the Provincial of the Jesuits the sixteenth of August, 1733. Saccheri died the twenty-fifth of October, 1733.

All preceding attempts were alike in trying to give a direct positive proof of the postulate; all were alike in the assumption open or hidden, conscious or unconscious, of an equivalent postulate.

Saccheri tries a wholly new way, and thus his book marks an epoch. He never doubted the absolute necessary truth of Euclid's postulate, and so he thinks that the two alternatives, possible if it be taken as not true, must each lead to some contradiction, to some absurdity. He tries the reductio ad absurdum. Ninety years later, 1823, Bolyai János reached the astounding conviction that these alternatives lead not to any contradiction but to the "science absolute of space," a generalization of Euclid's universe. In a letter dated the third of November, 1823, written in the Magyar language, and fortunately preserved for us at Maros Vásárhely in Hungary, Bolyai János writes to his father, Bolyai Farkas: "I have discovered such magnificent things that I am myself astonished at them. It would be damage eternal if they were lost. When you see them, my father, you youself will acknowledge it. Now I cannot say more, only so much: *that from nothing I have created another wholly new world.*"

Suppose we take a few steps into this new universe on the path which opened before Saccheri without his ever suspecting whither it led.

1. If two points determine a line it is called a straight.

2. If two straights make with a transversal equal alternate angles, they have a common perpendicular.

3. A piece of a straight is called a sect.

4. If two equal coplanar sects are erected perpendicular to a straight, if they do not meet, then the sect joining their extremities makes equal angles with them and is bisected by a perpendicular erected midway between their feet: [Proved by folding the figure over, along the third perpendicular].

5. Considering figures where the right angles made by the equal perpendiculars may be said to be not alternate, and where no two perpendiculars to the same straight meet, the equal angles made with the joining sect at the extremities of the two equal perpendiculars are either right angles, acute angles, or obtuse angles. Distinguish the three cases as hypothesis of right, hypothesis of acute, hypothesis of obtuse.

6. According to these three hypotheses respectively, the join of the extremities of the equal perpendiculars is equal to, greater than, or less than the join of their feet. [Saccheri, Prop. III. Translated by Halsted in the *American Mathematical Monthly*].

7. Inversely, according as the join of the extremities is equal to, or less than, or greater than the join of the feet, the equal angles will be right, or obtuse, or acute. [S. P. IV].

8. Corollary. In every quadrilateral containing three right angles and one obtuse, or acute, the sides adjacent to this oblique angle are less than the opposite sides, if this angle is obtuse, but greater if it is acute.

9. The hypothesis of right, if even in a single case it is true, always in every case it alone is true. [S. P. V.].

10. Assuming the principle of continuity, and referring only to figures where no two perpendiculars to the same straight meet; The hypothesis of obtuse, if even in a single case it is true, always in every case it alone is true. [S. P. VI.].

11. With like limitation; The hypothesis of acute, if even in a single case it is true, always in every case it alone is true. [S. P. VII.]

12. The sum of the angles of a rectilineal triangle is a straight angle in the hypothesis of right, is greater than a straight angle in the hypothesis of obtuse, is less than a straight angle in the hypothesis of acute. [S. P. IX].

13. The excess of a triangle is the excess of the sum of its angles over a straight angle. The deficiency of a triangle is what its angle-sum lacks of being a straight angle.

14. Two triangles having the same excess or deficiency are equivalent.

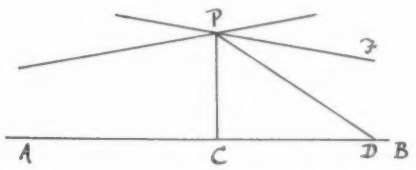
15. Even with the assumption that two straights cannot intersect in two points, the three hypotheses give rise to three perfect systems of geometry, the hypothesis of right to Euclid, the hypothesis of acute to Bolyai-Lobachevski, the hypothesis of obtuse to Riemann.

16. In the hypothesis of acute the straight is infinite. Two coplanar straights perpendicular to a third diverge on either side of their common perpendicular. The angle-sum of any rectilineal triangle is less than a straight angle.

17. In Euclid and Bolyai, parallels are straights on a common point at infinity.

18. In Bolyai, from any point P drop PC a perpendicular to a given straight AB.

If D move off indefinitely on the ray CB the sect PD will ap-



proach as limit PF copunctal with AB at infinity. PF is said to be at P the parallel to AB toward B.

PF makes with PC an angle CPF which is called the angle of parallelism for the perpendicular PC. It is less than a right angle by an amount which is the limit of the deficiency of the triangle PCD. On the other side of PC an equal angle of parallelism gives us the parallel at P to BA toward A.

Thus at any point there are two parallels to a straight.

A straight has two distinct separate points at infinity.

Straights through P which make with PC an angle greater than the angle of parallelism and less than its supplement do not meet the straight AB at all, not even at infinity.

19. A straight maintains its parallelism at all its points. [Lobachévski, Geometrical Researches on the Theory of Parallels, Translated by Halsted, § 17].

20. If one straight is parallel to a second, the second is parallel to the first. [L. § 18.].

21. Two straights parallel to a third toward the same part are parallel to each other. [L. § 25].

22. Parallels continually approach each other. [L. § 24].

23. The perpendiculars erected at the middle points of the sides of a triangle are all parallel if two are parallel. [L. § 30.]

24. If the foot of a perpendicular slides on a straight, its extremity describes a curve called an equi-distant curve or an equidistantial.

25. An equidistantial will slide on its trace.

26. A circle with infinite radius is not a straight but a curve, called the boundary curve, which is a plane curve such that all perpendiculars erected at the mid-points of chords are parallel. [L. § 31]. It is an equi-distantial whose base line is infinitely removed.

27. Circles, boundary-curves, equi-distantials cut at right angles a system of copunctal straights, of parallel straights, of perpendiculars to a straight, respectively.

Three points determine one of these curves; that is through any three points not co-straight will pass either a circle, a boundary-curve, or an equi-distantial, and only one such curve.

Any triangle may be inscribed in one and only one of these curves.

28. Boundary-surface we call that surface generated by the revolution of a boundary-curve about one of its axes.

Principal plane we call each plane passed through an axis of the boundary-surface.

Every principal plane cuts the boundary-surface in a boundary-curve.

Any other plane cuts the boundary-surface in a circle.

Boundary-triangles whose sides are arcs of the boundary-curve on the boundary-surface have the same interdependence of angles and sides and the same angle sum as rectilineal triangles in Euclid.

Geometry on the boundary-surface is the same as the ordinary Euclidean plane geometry. [L. § 34].

29. Triangles on an equidistant surface are similar to their projections on the base plane; that is, they have the same angles and their sides are proportional.

30. In the hypothesis of obtuse, a straight is of finite size, and returns into itself.

This size is the same for all straights. Any two straights can be made to coincide.

Two straights always intersect.

Two straights perpendicular to a third intersect at a point half a straight from the third either way.

A straight in the hypothesis of obtuse does not divide the plane into hemiplanes.

Starting from the point of intersection of two straights and passing along one of them over a certain finite sect, we come again to the intersection without having crossed the other straight.

This sect is the whole straight, and so a straight has not really two sides.

There is one point through which pass all the coplanar perpendiculars to a given straight. It is called the pole of that straight, and the straight is its polar.

A pole is half a straight from its polar. A polar is the locus of coplanar points half a straight from its pole. Therefore if the pole of one straight lies on another straight, the pole of this second straight is on the first straight.

The cross of two straights is the pole of the join of their poles.

The equidistantial is a circle with center at the pole of its basal straight.

Three straights each perpendicular to the other two form a tri-rectangular triangle. It is self-polar, each vertex being the pole of the opposite side.

In the hypothesis of obtuse, any two straights enclose a plane figure, a digon.

Two digons are congruent if their angles are equal.

In the hypothesis of obtuse, all perpendiculars to a plane meet at a point, the pole of the plane. It is the center of a system of spheres of which the plane is a limiting form when the radius becomes equal to half a straight.

Figures on a plane can be projected from similar figures on any sphere which has the pole of the plane for center. They have equal angles and corresponding sides in a constant ratio depending only on the radius of the sphere.

Geometry on a plane is therefore like two-dimensional spherics, but the plane corresponds to only a hemisphere.

The plane is unbounded but not infinite. It is finite in extent. The universe is unbounded but not infinite. It is finite in extent, or content, or volume.

Now of these three possible geometries of uniform space, Euclid's has the unexpected disadvantage that it can never be proved to be the system actual in our external physical world. To establish Euclid, it would be necessary to show that the angle-sum of a triangle is *exactly* a straight angle; and no measurements can ever reach exactitude.

To prove one of the others, we have only to show that the sum of the angles of some triangle is *less than*, or *greater than* a straight angle, which may conceivably be done even by inexact measurements.

What changes ought to be made in teaching elementary geometry in consequence of these later discoveries and the principles of the non-Euclidean geometries?

We are given a new criterion for questions of method, of exposition. For example, surface spherics attains a new importance.

When properly founded and expounded, pure spherics, two-dimensional spherics, while giving all the old results and laying the foundation for spherical trigonometry, gives also a picture of the planimetric part of Riemann's geometry, and becomes a touchstone for detecting the fallacies and assumptions in the many pseudo-proofs accepted in the past, such as attempts to found parallelism on direction, attempts to prove all right angles equal, etc.

As another example, we see a new stress laid on the incalcula-

ble advantages, educational and scientific, of Euclid's procedure in deducing from three assumed constructions every other construction before he uses it in any demonstration. The glib method of *supposed* solutious to all desired problems, of hypothetical constructions, is now seen in its deformity and danger.

Euclid says, under the heading "Postulates:"

"I. It is assumed, that a straight line may be drawn from any one point to any other point.

"II. And that a terminated straight line [a sect] may be produced in a straight line continually.

"III. And that a circle may be described with any center and radius."

From these Euclid rigidly deduces every problem of construction he wishes to use. Says Helmholtz: "In drawing any subsidiary line for the sake of his demonstration, the well-trained geometer asks always if it is possible to draw such a line. It is notorious that problems of construction play an essential part in the system of geometry. At first sight these appear to be practical operations, introduced for the training of learners; but in reality they have the force of existential propositions. They declare that points, straight lines, or circles, such as the problem requires to be constructed, are possible under all conditions, or they determine any exceptions that there may be."

Euclid's first three propositions are problems.

The most popular American geometry, Wentworth's, (1899), puts Euclid's two first postulates on page 8, and the third postulate a whole book later, and then never has a single problem of construction until page 112, where he says: "Hitherto we have supposed the figures constructed."

Meantime, on page 88, he gives as a "theorem:" "Through three points not in a straight line, one circumference, and only one, can be drawn.

He gives as his "Proof. Draw the chords AB and BC. At the middle points of AB and BC suppose perpendiculars erected. These perpendiculars will intersect at some point O, since AB and BC are not in the same straight line."

Now the tremendous existential import of the problem, to draw a circle through three non-costraight points, will be recognized when I say that in general it is not possible. In the Lobachevski geometry not every triangle has its vertices concyclic. Granting that every three points must be costraight or concyclic, we prove the parallel-postulate.

Of the possible geometries we cannot say *a priori* which shall be that of our actual space, the space in which we move.

The hereditary geometry, the Euclidean, is underivable from real experience alone, and can never be proved by experience. Euclidean space is, at least in part, a creation of the human mind. Its adequacy as a subjective form for experience has not yet been disproved. It can never be proved.

The realities which with the aid of our subjective space form we understand under motion and position, may, with the coming of more accurate experience, refuse to fit in that form.

Our mathematical reason may decide that they would be fitted better by a non-Euclidean space form.

Comparative geometry finally overthrows that superficial method which pretends to found a logically sound exposition of geometry on "direction," undefined.

For more than 20 years Wentworth gave his definition "A straight line is a line which has the same direction throughout its whole extent." (1877, Def. 8. 1886, p. 4; 1888, § 17).

At last he discards his aged error, and takes the definition of non-Euclidean geometry, "a straight is the line determined by two points" (1899, §§ 36 and 46).

Though the Bolyai and the Riemann geometries are founded on the straight, yet to say in them of two straights that they have the same direction has no ordinary meaning, since in Riemann every two straights cross and inclose a space, while in Bolyai every two parallels continually approach each other.

So as to direction, Wentworth has reformed, after 20 years in the land of nod.

But he still says, 1899, § 49, "A straight line is the shortest line that can be drawn from one point to another."

Now a relation of equality or inequality between two magnitudes must have some foundation, and be capable of some intelligible test. In the traditional geometry the foundation of all proof by Euclid's method consists in establishing the congruence of magnitudes.

To make the congruence evident, the geometrical figures are supposed to be applied to one another, of course without changing their form and dimensions. But since no part of a curve can be congruent to any piece of a straight, so, for example, no part of a circle can be equivalent to any sect from the definition of equivalent magnitudes as those which can be cut into pieces congruent in pairs.

In any comparison of size by congruence, we must be able to place one of the magnitudes or portions of it in complete or partial coincidence with the other. No such direct comparison

can be instituted between a straight and a line no piece of which is straight. Thus the whole of Euclid's *Elements* fails utterly to institute or prove any relation as regards size between a sect and an arc joining the same two points. The operation of measurement we cannot effect, rigorously speaking, either for curves or for curved surfaces, since the unit for length is a sect, and the unit for area, the square on that sect. In fact, however little may be the parts of a curve, they do not cease to be curved, and consequently they cannot be compared directly with a sect; just as parts of a curved surface are not directly comparable with portions of a plane.

We cannot even affirm that any ratio exists between a circle and its diameter until after we have made some extra-Euclidean and post-Euclidean assumption at least equivalent to the following:

No arc is less than its chord; and no minor arc is greater than the sum of the tangents at its extremities. If the curve be other than a circle we assume that on it one can always take two points so near that the arc between these points is not less than its chord, nor greater than the broken line formed by the two tangents touching its extremities. Some such assumption is, in fact, necessary, but it destroys by itself the primitive idea of measuring curves with straights.

Duhamel gives the assumption the following form: The length of a curve shall be the limit toward which the length of a broken line made up of consecutive chords of that curve approaches, when the number of chords is increased in such a manner that the chords all approach zero as limit.

Thus the evaluation of the length of a curve represents not at all an attempt at rectification strictly; but it has for aim the finding of a limit to which another magnitude would approach.

In geometry one proves that as the subdivisions are increased and the sides tend toward the limit zero, the perimeter of the polygon inscribed in a circle increases, circumscribed decreases, toward the same limit, which then is assumed for the magnitude of the circle.

Therefore when Phillips and Fisher, of Yale, give as their definition of a straight (1898, p. 4, § 7. Def.) "A *straight line* is a line which is the shortest path between any two of its points," they pass through and beyond Euclid's *Elements* to give us his simplest element; they institute a comparison not only with circular arcs, but also with all curves known and unknown; they presuppose a foreknowledge of all lines in a definition of the simplest

line. Is it still needful to say this is grossly bad logic, bad pedagogy, bad mathematics.

This same Yale geometry blunders horribly on p. 23, where it says: "In fact, Lobatchewsky in 1829 proved that we can never get rid of the parallel axiom without assuming the space in which we live to be very different from *what we know it to be through experience.*

Lobatchewsky tried to imagine a different sort of universe in which the parallel axiom would not be true. This imaginary kind of space is called *non-Euclidean* space, whereas *the space in which we really live* is called *Euclidean*, because Euclid (about 300 B. C.) first wrote a systematic geometry of our space."

The scientific doctrine of evolution postulates a world independent of man, and teaches the outcome of man from lower forms of life in accordance with wholly natural causes. In this world of evolution experience is a teacher, but man is a creator, and the mighty examiner is death.

The puppy born blind must still be able, guided by the sense of smell, to superimpose his mouth upon a source of nourishment. The little chick, responding to the stimulus of a small bright object, must be able to bring his beak into contact with the object so as to grasp and then swallow it. The springing goat that misjudges an abyss is lost.

So too with man. His ideas must in some way correspond to this independent world, or death passes upon him an adverse judgment.

But it is of the very essence of the doctrine of evolution that man's metric knowledge of this independent world, having come by gradual betterment and through imperfect instruments, for example the eye, cannot be absolute and exact.

The results of any observations are always with certain definite limitations as to exactitude and under particular conditions.

Man the creator replaces these results by assumptions presumed to have absolute precision and generality, such as, for example, the so-called axioms of Euclid.

If two natural hard objects, susceptible of high polish, be ground together, their surfaces in contact may be so smoothed as to fit closely together and slide one on the other without separating. If now a third surface be ground alternately against each of these two smooth surfaces until it accurately fits both, then we say that each of the three surfaces is approximately plane, is a piece of a plane.

If one such plane be made to cut through another, we say the common line where they cross is approximately a straight.

The perfect, the ideal plane is a human creation under which we seize the imperfect data of experience.

If three approximate planes on real objects be made to cut through a fourth approximate plane, then three approximate straights are formed on this fourth plane, and in general they are found to intersect, and the figure they make we may call an approximate triangle.

Such triangles may vary greatly in shape. But no matter what the shape, if we cut off the six ends of any two such, and place them side by side on a plane with their vertices at the same point, the six are found with a high degree of approximation just to fill up the plane about the point. If the whole angular magnitude about any point in a plane be called a perigon, then we may say that the six angles of any two approximate triangles are found to be together approximately a perigon.

Now does the exactness of this approximation to a perigon depend only on the straightness of the sides of the original two triangles, or also upon the size of these triangles?

If we know with absolute certitude that the size of the trianangles has nothing to do with it, then we know something that we have no right to know according to the doctrine of evolution, something impossible for us ever to have learned evolutionally.

Yet before the epoch-making ideas of Bolyai János and Lobachevski, everyone supposed we were perfectly sure that the angle-sum of an actual approximate triangle approached a straight angle with an exactness dependent only on the straightness of the sides and not at all on the size of the triangle.

But if in the mechanics of the world independent of man we were absolutely certain that all therein is Euclidean and only Euclidean, then Darwinism would be disproved by the reductio ad absurdum.

All our measurements are finite and approximate only.

The mechanics of actual bodies in what Cayley called the external space of our experience, might conceivably be shown by merely approximate measurements to be non-Euclidean, just as a body might be shown to weigh more than two grams or less than two grams, though it never could be shown to weigh precisely, absolutely two grams.

The outcome of the non-Euclidean geometry is a new freedom to explain and understand our universe and ourselves.

SPECTROSCOPIC NOTES.

Arrangements for observing the total eclipse of May 28 have been so far completed as to insure adequate observation by well equipped expeditions. Most of the large observatories will be represented by observing parties, usually of several trained observers, well reinforced by amateur enthusiasts. The stations are chosen for the most part in North Carolina, Georgia, and eastern Alabama; in fact they are probably less widely distributed than they should be. Given only good weather, valuable results seem certain.

Popular interest in the eclipse and its results is evidently considerable. In view, however, of the importance, beauty, and rarity of the phenomenon, this interest ought, much more frequently than seems now to be the case, to take the form of planning to be present in person in the path of totality.

Mr. J. Lunt, *Proceedings of the Royal Society* No. 425, describes experiments which led him to ascribe certain lines in some of the helium stars to silicon. Like Sir Norman Lockyer he found these lines given off by vacuum tubes under a strong disruptive spark, and traced them to silicon derived from the glass of the tubes. In experiments with silicon tetrafluoride the differences in the behavior of silicon under different circumstances of discharge were exhibited in a striking manner.

Professor Campbell (*Astrophysical Journal*, March) finds a variable velocity in the line of sight for β Herculis The period of the variation is unknown, but seems to be long.

In the *Astronomische Nachrichten*, No. 3629, Dr. K. Schwartzschild publishes a modification of the method of Professor Lehman Filhés for the computation of the orbit of a spectroscopic binary, by which the labor of the process is abridged.

Publications of Sir William Huggins' Observatory, Vol. I (William Wesley and Son, London) contains Sir William and Lady Huggins' Atlas of Representative Stellar Spectra from λ 4870 to λ 3300. The volume opens with a short history of the Observatory, and contains, with the Atlas, a discussion of the evolutional order of the stars and the interpretation of their spectra.

In the *Astrophysical Journal* for March Professor Campbell gives the theory of the velocity of the Moon in the line of sight. As Venus and Mars are not always available to test the accuracy of measures of radial velocity it is sometimes desirable to obtain spectrograms of the Moon for the purpose. The distance, place of observation to Moon plus Moon to Sun, the change of which is the effective radial velocity of the Moon, may vary at a rate almost as great as two kilometers per second. This motion is divided into several parts, the expression for each of which is so arranged as to be easily computed from data given in the Nautical Almanac. In an example Professor Campbell finds for the computed velocity + 1.14 kilometers for second, and for the measured velocity + 1.46 km. per second.

In his annual report President Eliot of Harvard University states that Mrs. Fleming, whose name appears in the University catalogue as Curator of Astronomical Photographs, is believed to be the first woman who has held an official position in Harvard University.

The February number of the *Monthly Notices of the Royal Astronomical Society* contains the annual report of the Council. The Proceedings of Observatories contain, in a number of cases, reference to spectroscopic work. At the Cape of Good Hope the McClean photographic equatoreal has been used with the slit spectroscope for the study of star spectra, yielding the discovery of oxygen and of silicon in certain stars; the object-glass has now, however, been returned to the maker for correction. At Cambridge the work on star spectra with the Bruce spectroscope has been brought to a conclusion. At Stonyhurst a study of the Sun with a grating spectroscope has shown about the same degree of solar activity in 1899 as in 1898; also, the stellar spectrograph has been used to continue the investigation of possible changes in certain selected stars. At Wolsingham the search for stars with remarkable spectra has been continued with success.

Of the summary of progress of astronomy during the year spectroscopic work is the subject of about one-fourth. The advance in stellar spectroscopy is summarized in a compact article occupying four pages, while two pages are devoted to a review of Sir William and Lady Huggins' Atlas of Representative Star Spectra.

Mr. Wright (*Astrophysical Journal*, March) has computed the orbit of the spectroscopic binary χ Draconis from the results of 28 plates obtained with the Mills spectrograph of the Lick Observatory. For the projection in the line of sight of the major axis he finds 62,000,000 kilometers (39,000,000 miles), with a probable error of 400,000 km. (260,000 mi.); for the eccentricity 0.423, with probable error 0.006; and for the period 281.8 days, with probable error 0.7 days. The spectrum of χ Draconis, resembling that of Procyon, with the $H\gamma$ line of hydrogen well defined and the metallic lines sharp and well separated, was very suitable for measurement.

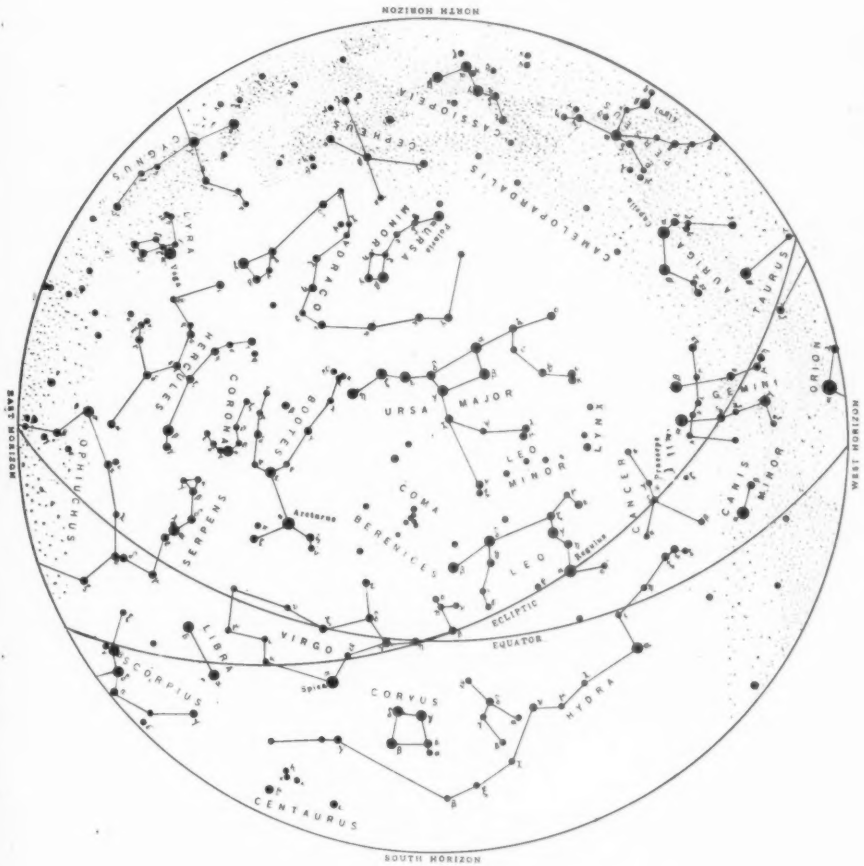
The death of Miss Catherine W. Bruce removes a very liberal friend of astronomical science, by whose ready and well directed financial aid the construction of much important spectroscopic and photographic apparatus and the prosecution of many valuable researches have been made possible.

PLANET NOTES FOR MAY.

H. C. WILSON.

Mercury is morning star, but too close to the Sun to be observed. At the time of the total eclipse Mercury will be just a little way west from the Sun as shown upon the eclipse chart No. 3, given in this number of POPULAR ASTRONOMY. It will doubtless be visible during totality of the eclipse and observers not in the path of totality might well spend some time in looking for the planet at the time of maximum eclipse. Mercury will then be so near superior conjunction that its disc will be fully illuminated and if those markings which Mr. Lowell's observers at Flagstaff saw so plainly are ever to be seen by others this should be the time. It is true Mercury will be on the farther side of the Sun and and its disc will be small, yet this would only reduce the size of the markings by one-half. For those, therefore, whose time is not occupied with the study of the corona and who have the use of telescopes with apertures of six inches and up-

wards, it may be well worth the while to study this planet carefully. Mercury will reach superior conjunction on the morning of May 30, being very near perihelion at the same time, and after that will be evening star.



THE CONSTELLATIONS AT 9 P. M., MAY 1, 1900.

Venus has just passed greatest elongation east from the Sun and will this month turn in toward the line joining Earth and Sun. The phase of Venus is now like that of the half Moon and will decrease gradually during the month. The planet, however, will continue to rapidly approach the Earth so that its brilliancy will still increase up to the first of June. Venus, the Moon, the Pleiades and the Hyades made a very pretty group in the western evening sky on

April 2. Venus will be in conjunction with the Moon again on May 2 but the Pleiades and the Hyades will be far down toward the west at that time. Again on May 31 there will be another conjunction of Venus and the crescent Moon.

Mars is morning star about 22° west from the Sun, declination 6° north. Its angular distance from the Sun and its northern declination will steadily increase throughout the summer and so the planet will come into more and more favorable position for observation. Mars will be in conjunction with Mercury on May 3, Mars being 2° north of Mercury. At the time of the total eclipse of the Sun, May 28, Mars will be near the meridian toward the south, and will no doubt be visible to the naked eye at the time of totality.

Jupiter will be at opposition May 27 and so may be best observed during the two hours before and after midnight.

Saturn may be observed between midnight and morning, being seen low in the south or southeast, according to the hour of observation, in the constellation Sagittarius.

Uranus is near Jupiter, in Scorpio, and may be observed at the same hours.

Neptune is now low in the west in the evening, in the constellation Taurus, and practically out of position for observation for the remainder of this year.

Phenomena of Jupiter's Satellites.

Central Standard Time.

		h	m					h	m		
May	1	9	52 P. M.	I	Sh. In.	May	17	1	28 A. M.	I	Oc. Re.
		10	28 "	I	Tr. In.			8	09 P. M.	I	Sh. In.
	2	12	05 A. M.	I	Sh. Eg.			8	23 "	I	Tr. In.
		12	40 "	I	Tr. Eg.			10	22 "	I	Sh. Eg.
		10	00 P. M.	I	Oc. Re.			10	35 "	I	Tr. Eg.
	5	10	27 "	II	Ec. Dis.		21	10	40 "	II	Sh. In.
	6	1	51 A. M.	II	Oc. Re.			10	58 "	II	Tr. In.
		10	52 P. M.	III	Sh. In.		22	1	07 A. M.	II	Sh. Eg.
	7	12	48 A. M.	III	Sh. Eg.			1	22 "	II	Tr. Eg.
		12	57 "	III	Tr. In.		24	12	57 "	I	Ec. Dis.
		2	35 "	III	Tr. Eg.			3	12 "	I	Oc. Re.
		8	53 P. M.	II	Tr. Eg.			9	08 P. M.	III	Ec. Dis.
	8	2	40 A. M.	I	Ec. Dis.			10	03 "	I	Sh. In.
		11	46 P. M.	I	Sh. In.			10	07 "	I	Tr. In.
	9	12	13 A. M.	I	Tr. In.			11	06 "	III	Oc. Re.
		1	59 "	I	Sh. Eg.		25	12	16 A. M.	I	Sh. Eg.
		2	25 "	I	Tr. Eg.			12	19 "	I	Tr. Eg.
		9	09 P. M.	I	Ec. Dis.			7	25 P. M.	I	Ec. Dis.
		11	44 "	I	Oc. Re.			9	39 "	I	Oc. Re.
	10	8	28 "	I	Sh. Eg.		29	1	12 A. M.	II	Tr. In.
		8	51 "	I	Tr. Eg.			1	14 "	II	Sh. In.
	13	1	01 A. M.	II	Ec. Dis.			3	36 "	II	Tr. Eg.
		4	07 "	II	Oc. Re.			3	42 "	II	Sh. Eg.
	14	2	49 "	III	Sh. In.		30	7	21 P. M.	II	Oc. Dis.
		4	16 "	III	Tr. In.			9	55 "	II	Ec. Re.
		8	45 P. M.	II	Tr. In.		31	2	53 A. M.	I	Oc. Dis.
		10	33 "	II	Sh. Eg.			4	59 "	I	Ec. Re.
		11	09 "	II	Tr. Eg.			11	51 P. M.	I	Tr. In.
	16	1	40 A. M.	I	Sh. In.			11	57 "	I	Sh. In.
		1	57 "	I	Tr. In.	June	1	12	41 A. M.	III	Oc. Dis.
		3	53 "	I	Sh. Eg.			2	03 "	I	Tr. Eg.
		4	09 "	I	Tr. Eg.			2	10 "	I	Sh. Eg.
		11	02 P. M.	I	Ec. Dis.			2	52 "	III	Ec. Re.

NOTE.—In. denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., Eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Jupiter's Satellites for May.

Phases of the Eclipses of the Satellites for an Inverting Telescope.

I.

III.

II.

IV. No Eclipse.

Configurations at 11h 30m for an Inverting Telescope.

Day.	West.	East.
1	○ 1· ·3 ·2	○ 4·
2	·3 ○ ·1 ·2 4·
3	1· ○ 2· ·3 4·
4	2· ○ ·1 4· ·3
5	·1 ○ 4 3· 2●
6	4· ○ 3 1· 2·
7	4· 3· 1 2· ○
8	4· 3· ·2 ○ 1·
9	4· ·3 ○ ·2 ·1●
10	·4 1· ○ 3 2·
11	·4 2· ○ ·1 ·3
12	·4 1· ·2 ○ 3·
13	·4 ○ 3· 1· ·2
14	3· ·1 2· ○ ·4
15	3· ·2 ○ 1· ·4
16	·3 ○ ·2 ·4 ·1●
17	1· ○ ·3 2· ·3
18	2· ○ 1· ·3 3·
19	1· ·2 ○ 3· 4·
20	○ 3· ·1 ·2 4·
21	○ 2· 3· ·1 ○ 4·
22	3· ·2 4· ○ 1·
23	4· ·3 ·1 ○ ·2
24	○ 1· 4· ○ 2· ·3●
25	4· 2· ○ 1· ·3
26	·4 2 1· ○ 3·
27	·4 ○ 1 3· ·2
28	·4 3· ·1 ○ 2·
29	3· 4 ·2 ○ 1·
30	·3 ·1 ○ ·2 ·4●
31	·3 ○ 1· 2· ·4

VARIABLE STARS.

J. A. PARKHURST.

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

1900.

U CEPHEI.

	d	h
June	3	11
	5	22
	8	10
	10	22
	13	10
	15	22
	18	10
	20	21
	23	9
	25	21
	28	9
	30	21

S CANRCRI.

	d	h
June	9	2
	18	14
	28	1

δ LIBRAE.

	d	h
June	3	10
	5	18
	10	10
	12	18
	17	9
	19	17
	24	9
	26	17

U CORONAE.

	d	h
June	9	13
	13	0
	16	11
	19	22
	23	9
	26	19

U OPHIUCHI.

Every 10th min.
P = 20h.1

	d	h
June	2	14
	10	23
	19	9
	27	18

Z HERCULIS.

	d	h
June	3	14
July	1	13

2P = 3d 23h.8

W. DELPHINI.

	d	h
June	3	17
	8	13
	13	8
	22	23
	27	18

Y CYGNI.

Even min.

	d	h
June	2	15
July	2	14

2P = 2d 23h.9

Odd min.

	d	h
May	31	18
June	30	17

2P = 2d 23h.9

+ 45°3062.

	d	h
June	4	17
	9	7
	13	21
	18	11
	23	0
	27	14

Maxima and Minima of Long Period Variables.

1900 July.

MAXIMA.

Day.	Star.
3	RT Cygni
4	S Virginis
5	T Columbæ
5	V Geminorum
5	T Pegasi
6	U Bootis
9	V Cassiopeæ
10	S Leonis
12	V Libræ
13	U Lyræ
16	Z Virginis
17	W Lyræ
18	S Aquarii
18	R Ceti

MAXIMA.

Day.	Star.
20	U Cassiopeæ
20	Z Aquarii
20	RR Cygni
20	RZ Cygni
22	S Urase minoris
24	Y Virginis
25	R Capricorni
25	R Virginis
27	S Pegasi
28	W Ophiuchi
30	X Aquarii
31	*o* Ceti (Mira)
31	R Comae

MINIMA.

Day.	Star.
8	Z Ophiuchi
9	V Bootis
11	W Monocerotis
11	S Sagittarii
14	R Persei
19	S Cephei
20	T Cephei
28	S Arietis
29	—Pegasi*

NOTES TO THE EPHEMERIS.—For this month it contains only those stars which are given in Dr. Hartwig's ephemeris in the *Vierteljahrsschrift*, and the long period ephemeris is essentially in the form there given.

* The star "—Pegasi," whose minimum is given for June 29, is at 21h 16m 15s, + 14° 1′.6, (1900).

ADDITIONAL NOTES.

U GEMINORUM.—This star was found normal, 13.4 magnitude, by Zaccheus Daniel, 1900 March 28.57, Greenwich Time, and 9.8 magnitude by the writer, March 30.60. At this writing, April 9, it is still a little brighter than the 11th magnitude, showing it to be a "long" maximum.

SS CYGNI.—The late maximum was covered by 11 observations, 8 by Zaccheus Daniel and 3 by J. A. Parkhurst. It was found normal by Daniel 1900 March 2.91 (*i. e.* 11.2 magnitude); and slightly brighter, about 10.8 magnitude, March 3.50. It was found in full light, 8.46 magnitude, by Parkhurst, March 6.96. It reached normal light about March 23, showing this to be a maximum of the ordinary "long" type, duration 20 days. The strange thing is that the previous maximum, that of 1900 January, was also long. Previous to this, there has been no break in the regular alternation of short and long types, since the two successive short max ma of March and April, 1897, with the exception of the abnormal maximum of 1899 November, which did not interfere (at least immediately) with the regular order.

Report of Rousdon Observatory.*—Observations of long period variable stars during the year 1899, by Sir Cuthbert E. Peek, Bart., M. A., F. R. A. S., C. Grover, assistant.

On 167 nights in 1899 570 magnitude determinations were made. During the 14 years this work has been in progress 6,248 magnitude determinations have been made, each consisting of five visual comparisons. Thus during 1899, 3,420 estimates of brightness have been made.

Instrument used, a 6.4 inch Merz refractor, powers 34, 80 and 132. A 13.5 magnitude star is the limit of vision (on the H. C. O. photometric scale).

About 30 long period variables, mostly circumpolar, are systematically followed, continuously through the year. In 14 years, 245 maxima and 214 minima have been observed.

FOR 1899.

	MAXIMA.		MINIMA.			MAXIMA.		MINIMA.	
	T.	Mag.	T.	Mag.		T.	Mag.	T.	Mag.
T Cass.....	April 17	7.3	Sept. 29	11.3	R Urs. Min.....	———	———	Sept. 26	10.4
S "	———	———	June 15	12.7	R Draconis.....	June 18	7.6	Feb 27	11.9
S Persei.....	———	———	Dec. 4	10.0	R "	———	———	Nov. 26	13.3
R Aurigæ.....	April 17	6.9	———	———	S Herculis.....	Sept. 21	6.4	———	———
U Orionis.....	" 15	6.0	Nov. 26	11.8	T Draconis.....	Aug. 16	8.0	Feb. 28	12.1
R Lyncis.....	Aug. 9	6.5	Jan. 16	13.5	R Cygni.....	Feb. 19	7 3	———	———
R Urs. Maj....	" 12	7.6	Mar. 4	13 1				1898	
T " '	July 3	6.3	" 15	12.6	χ "	May 22	3.6	Dec. 20	12.6
T " "	———	———	Nov. 15	13.0				1899	
S " "	July 20	7.5	April 7	11.6	" "	———	———	Nov. 26	12.0
S " "	———	———	Oct. 30	12.2	S "	Mar. 4	10.2	———	———
S Bootis.....	July 3	8.3	Feb. 1	13.0		1898.			
S "	———	———	Nov. 20	13.0	T Cephei.....	Dec. 28	5.6	June 3	9.5
R Camelop.....	May 2	8.0	Jan. 6	< 13.0	S "	———	———	May 2	12.6
R "	———	———	Sept. 26	13.6	R Cass.....	June 3	5.8		

During the year 17 maxima and 22 minima have been observed.

Variable Star Notes No. 4, containing observations of *R* and χ Cygni for 10 years, 1887 to 1896, and No. 5. containing U Orionis and S Herculis for 13 years, 1886 to 1898, have been published and distributed.

* Extract from the *Journal of the British Astronomical Association.*

NEW VARIABLE STARS.

The star BD. + 46°2966 has been found variable from the photograph by Mr. A. Stanley Williams, and confirmed by Prof. Deichmüller. (A. N. Nos. 3629 and 3632). The position of the star is—

R. A. $20^h\ 28^m\ 9.7^s$, Dec. + 46° 6′ .1, (1855)
$29\ 38.0$ 10 .2, (1900)

The range so far observed has been from 7.0 to 10.0 magnitude. A period of 31.0 days satisfied the observations of Mr. Williams, but Prof. Deichmüller considers that it may be 15 days. This stamps it as a variable of unusual interest and it should be closely watched.

Rev. Anderson, has found to be variable an anonymous star in the position—

R. A. $20^h\ 8.5^m$, Dec. + 46° 12′, (1855)

The observed magnitudes are—

1900 Jan. 16, 8.8 1900 Feb. 20, 9.0
19, 8.7 Mar. 14, 9.5.

COMET AND ASTEROID NOTES.

Comet *a* 1900 (Giacobini).—In *Astronomische Nachrichten* No. 3627, Dr. Berberich gives the following approximate ephemeris of Giacobini's comet, which shows that the comet will be nearest the Earth about Aug. 1, but that it will be brightest theoretically about July 1. It will be favorably situated for observation during all of the summer, but will become rapidly fainter in the autumn, because of its recession from the Earth.

EPHEMERIS OF COMET *a* 1900.

		R. A. h m	Decl. ° ′	log r.	log Δ.	Br.
April	27	1 33.2	+ 17 28	0.1245	0.3622	0.93
May	29	1 09.0	+ 27 07	0.1483	0.2862	1.18
June	30	23 46.9	+ 41 31	0.2085	0.1376	1.77
Aug.	1	19 36.3	+ 41 20	0.2794	0.0778	1.68
Sept.	2	17 39.2	+ 17 50	0.3472	0.2623	0.53
Oct.	4	17 23.2	+ 5 55	0.4081	0.4316	0.18

Ephemeris of Asteroid (11), Parthenope.

		R. A. h m s	Decl. ° ′ ″	log Δ.
May	2	16 10 14.9	− 13 36 58	0.1585
	6	7 07.9	13 25 29	0.1521
	10	3 43.4	13 14 14	0.1468
	14	16 00 05.1	13 03 26	0.1427
	18	15 56 17.3	12 53 21	0.1399
	22	52 24.5	12 44 11	0.1383
	26	48 31.6	12 36 11	0.1380
	30	15 44 43.5	− 12 29 36	0.1390

Opposition, May 21. Magnitude = 9.1.

GENERAL NOTES.

We have added sixteen pages to the usual size of this publication to print a revise of Professor Halsted's article on Non-Euclidean Geometry. Bad service by an express company makes this necessary.

Goodsell Observatory Eclipse Expedition.—We are now planning for a trip to the line of totality of the eclipse of May 28, 1900, at a point probably in North Carolina. If such a plan should be carried out, the next issue of this publication will be delayed until about the middle of June.

Note Supplemental to Paragraph Ending near Bottom of Page 229.—Since writing that paragraph satisfactory results, as far as contrast is concerned, have been obtained by the use of a strong hydrochinon developer. By this means all the contrast needed can be obtained even on the most rapid plates, without in the least diminishing their rapidity. For my own work I intend to use Seed 27 plates exclusively. Some of the negatives of the inner corona, where plenty of contrast is usually shown, will be developed with rodinal, one part in thirty-two of water. All negatives of the outer corona will be developed with hydrochinon, by Cramer's formula. By this plan, since rapid plates may be used instead of slow ones, the exposures above recommended may be reduced from ten to fifteen times.

CRAMER'S HYDROCHINON DEVELOPER.

I.

Water	25 oz.
Sulphite of Sodium Crystals	3 "
Hydrochinon	½ "
Bromide of Potassium	¼ "

II.

Water	25 oz.
Carbonate of Sodium Crystals	6

Mix equal parts for use, and develop not over six or eight minutes at a temperature of 70°. Carbonate of Sodium Crystals 6 oz. (also called Sal Soda or Washing Soda) are equivalent to 2½ oz. when pulverized and dried. Sulphite of Sodium 3 oz. are equivalent to 1½ oz. when dried or granulated.

WILLIAM H. PICKERING.

MEADOW VIEW, Chatham, N. J., April 16, 1900.

EDITOR OF POPULAR ASTRONOMY:—Will you allow me, through your magazine, to call the attention of readers of my book, "*Star-Names and their Meanings*," to my error in omitting to give his due share of credit to R. T. A. Innes, Esq., of the Royal Observatory at the Cape of Good Hope in the discovery of the new "runaway star" in Pictor. This omission occurred on page 214, and is repeated on page 446 in the remarks on "1830 Groombridge," where I assigned the discovery solely to Professor Kapteyn, making no reference to Mr. Innes.

I exceedingly regret this omission, and all the more as the original announcement by Professor Katepyn in the *Nachrichten*, No. 3466, was explicit as to Mr. Innes' large share in the discovery.

As the latter has sent me the Royal Observatory *Report* for 1897, with the detailed history of the discovery, I transcribe and inclose what Doctor Gill, the Director of the Observatory, has to say on the subject. Some part, or indeed the whole, of this you may think of interest in your columns, for the star in question, as you know, shows the greatest proper motion as yet determined.

RICHARD HINCKLEY ALLEN.

Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the year 1897, 1898.—"But by far the more interesting result of this examination has been the discovery of an 8th magnitude star having annual proper motion amounting to nearly 9″ of arc in the great circle, *the largest proper motion yet known.*

In regard to this star (No. 8 of List I.) Kapteyn had remarked—No. 8, $5^h\ 6^m\ 40^s.6$, 44° 58′.2, Z. C. V. 243, Mag. 8. 'Certainly missing on two plates.'

On 1897, February 2d, Mr. Innes looked for this star, and found none in the given position, but he found a full yellow star, 8.3 Mag., about 15 seconds in R. A. from the required place. The following day I transmitted to Professor Kapteyn this note of Mr. Innes, with his query 'Do you find the star $5^h\ 6^m\ 56^s.0$, 44° 58′ on the C. P. D. plates? It is difficult to think the Z. C. wrong 15^s on two occasions, or that the bright star $5^h\ 6^m\ 56^s$ could have been overlooked. Can this be proper motion?'

On August 24th Kapteyn wrote requesting that the star in question should be again looked up, because the observations now stood thus:

		Mag.	α		δ	
Gould, Z. C.	1873.0	8	$5^h\ 6^m$	$40^s.6$	— 44° 58′.2	2 obs.
C. P. D.	1890.1	9 2	6	50 .8	59 .5	4 obs.
Innes	1897.0	8.3	6	56 .0	58.0	——

The R. A. agreeing very well on the supposition of a proper motion of $0^s.64$, but not so the Declinations. Could there be a mistake in Mr. Innes' Declination?

On September 22 I replied that there was no doubt that the star C. Z. V. 243 is the star of greatest known proper motion, that Innes' observation of 1897.0 had not been an observation in Declination, because finding no star in the required R. A., he had simply noted the neighboring star differing 15^s in R. A. and having *about* the same Declination as the missing star. But on February 15th he had re-observed the star and found $\alpha\ 5^h\ 6^m\ 56^s$, δ — 45° 0′.4, and that the estimated motion of the star on one of the catalogue plates made a proper motion of about + $0^s.64$ and — 0′.1 in Declination certain.

On October 27th I forwarded results of two meridian observations of the star made on October 23d and 24th. A preliminary note has been communicated to the *Astr. Nach.*, No. 3464, by Professor Kapteyn. A complete investigation of the proper motion and parallax of this remarkable object will be made at the Cape."

Professor Henry S. Pritchett, Superintendent of the Coast and Geodetic Survey, has resigned his place to accept the presidency of the Massachusetts Institute of Technology of Boston. He was the youngest superintendent that the Coast Survey has ever had, and he has been one of the most capable.—*Scientific American,* April 14.

Rotation of Venus.—A telegram has been received at the Harvard College Observatory from Professor Kreutz at Kiel, Germany, stating that he has information from Professor Backlund, Director of the Observatory at Pulkowa, Rus-

sia, that, from a discussion of spectrograms, Belopolsky has found the time of rotation of Venus to be short.

This telegram was distributed to American astronomers April 10. It will be remembered by the reader that there has been considerable dispute between observers of the surface markings of Venus, as to whether the period of rotation is approximately twenty-four hours or is equal to the period of revolution around the Sun, 225 days. We shall await with great interest the details of Professor Belopolsky's observations.

The Total Solar Eclipse of May 28.—So far as known at present, the arrangement of British observing parties is as follows:

OFFICIAL EXPEDITIONS.

Ovar.—The Astronomer Royal will take large scale photographs of the corona, using the Thompson 9 inch object-glass and telephoto concave magnifier to obtain photographs on the scale of 4 inches to the Sun's diameter on 15 by 15 inch plates. The double tube with a 4-inch rapid rectilinear lens of 33-inch focus and a special rapid lens of about 13 inches focus will be used in an attempt to obtain photographs of long extensions of the corona. Mr. Dyson will have in his charge two slit spectroscopes belonging to Capt. Hills and used by him in India in 1898, with which to photograph the spectrum of the flash and of the corona.

Alicante.—Sir Norman Lockyer, who will probably be accompanied by Mr. Fowler and Dr. Lockyer, will be stationed near the central line south of Alicante. The chief instruments to be used here are prismatic cameras, one of which will have an aperture of 6 inches and a focal length of 20 feet.

Algiers.—Professor Turner and Mr. Newall, will be stationed at the Observatory of which M. Trepied is Director. Prof. Turner will have one of the double tubes which have been used in several previous eclipses. One section will be fitted with apparatus for photographing the corona by polarized light, the other will possibly be utilized for taking ordinary photographs of the corona. Mr. Newall will use: (A) a four-prism slit spectroscope for photographing the spectrum (i) of the flash, (ii) of the corona; (B) an objective grating camera for photographing the corona in monochromatic light; (C) a polariscope camera for photographing the corona.

Prof. C. V. Boys and Mr. Wesley will probably be also members of the official party at Algiers.

Mr. Evershed, will proceed to a spot about 20 miles south of Algiers, which is just within the limit of totality. This place is chosen, as it is his purpose to obtain photographs of the "flash" spectrum of as long duration as possible, and near the Sun's pole.

British Astronomical Association Expeditions. Algiers.—Mr. and Mrs. Maunder and family, will take short exposure photographs of the inner corona, and will also take photographs of long exposure for extensions. A prismatic opera glass will be used, if circumstances will allow. Mr. and Mrs. Crommelin, will use a tele-photo lens of about 80 inches, equivalent focal length and aperture 1½ inches to take photographs of the inner corona. They will also observe times of contact, and make sketches at the telescope of detail of the inner corona.—*The Observatory, April*, 1900.

Observatories in the United States having Refracting Telescopes.—From the Congressional Record of April 11, we copy the following list of telescopes in the United States:—

Observatory.	Aperture.	Director.	Location.
	Inches.		
Yerkes (University of Chicago)	40	George E Hale	Williams Bay, Wis
Lick (University of California). [See also Students' Observatory below.]	36	J. E. Keeler	Mount Hamilton, Cal.
Naval, United States	26	C. H. Davis	Washington, D. C.
Leander McCormick (University of Virginia),	26	Ormond Stone	Charlottesville, Va.
Lowell	24	A. E. Douglass	Flagstaff, Ariz.
Halstead (Princeton University)	23	Charles A. Young	Princeton, N. J.
Chamberlin (University of Denver)	20	Herbert A. Howe	University Park, Colo.
Smithsonian Institution	20	Samuel P. Langley	Washington, D. C.
Northwestern (Dearborn) University	18.5	G. W. Hough	Evanston, Ill.
Flower	18	C. L. Doolittle	Upper Darby, Pa.
Goodsell (Carleton College)	16	Wm. W. Payne	Northfield, Minn.
Lowe	16	Lewis Swift	Echo Mountain, Cal.
Washburn (University of Wisconsin)	15.6	George C. Comstock	Madison, Wis.
Harvard College	15	Edward C. Pickering	Cambridge, Mass.
University of Mississippi	15	Chancellor R. B. Fulton	Oxford, Miss.
Litchfield (Hamilton College)	13.5	S. T. Saunders	Clinton, N. Y.
Columbia University	13	John K. Rees	New York City.
Western University of Pennsylvania	13	F. L. O Wadsworth	Allegheny, Pa.
Detroit (University of Michigan)	12.75	A. Hall, jr	Ann Arbor, Mich.
Morrison	12.5	C. W. Pritchett	Glasgow, Mo.
Emerson McMillin (Ohio State University)	12.5	Henry C. Lord	Columbus, Ohio.
Dudley	12	Lewis Boss	Albany, N. Y.
West Point (United States Military Academy)	12	Professor Peter S. Michie	West Point, N. Y.
Ladd (Brown University)	12	Winslow Upton	Providence, R. I.
Vassar College	12	Mary W. Whitney	Poughkeepsie, N. Y.
Wesleyan University	12	John M. Van Vleck	Middletown, Conn.
University of Cincinnati	11	J. G. Porter	Cincinnati, Ohio.
Daniel Scholl (Franklin and Marshall College)	11	J E. Kershner	Lancaster, Pa.
Smith (Hobart College) [See also Hobart College below.]	10	Wm. R. Brooks	Geneva, N. Y.
Lawrence University	10	F. E. Millis	Appleton, Wis.
Bucknell University	10	W. C. Bartol	Lewisburg, Pa.
Haverford College	10	Wm. H Collins	Haverford, Pa.
Johns Hopkins University	9.5	Simon Newcomb	Baltimore, Md.
McKim (De Pauw University)	9.5		Greencastle, Ind.
Beloit College	9.5	Clement Rood	Beloit, Wis.
Shattuck (Dartmouth College)	9.4	Edwin B. Frost	Hanover, N. H.
Hartford Public High School	9.5	B. S. Annis	Hartford, Conn.
Catholic University	9	G. M. Searle	Washington, D. C.
Hobart College [See also Smith Observatory above]	8.75	H. L. Smith; Wm. R. Brooks	Geneva, N. Y.
Vanderbilt University	8.5	Wm. J. Vaughn	Nashville, Tenn.
Yale University	8	W. L. Elkin	New Haven, Conn.
Durfee High School	8	Iram N. Smith	Fall River, Mass.
Iowa College	8	S. J. Buck	Grinnell, Iowa.
Mount Holyoke College	8	Miss A. S. Young	South Hadley, Mass.
Alabama University	8	H. A. Sayre	Tuscaloosa, Ala.
Holden Memorial (Syracuse University)	8	Henry A. Peck	Syracuse, N. Y.
Annapolis (United States Naval Academy)	7.75	Lieut. Com'd. C. W. Bartlett	Annapolis, Md.
University of Missouri	7.5	J. N. Fellows	Columbia, Mo.
Amherst College	7.25	David P. Todd	Amherst, Mass.
Boston University	7.1	J. B. Colt	Boston, Mass.
University of Illinois	6	G. W. Myers	Urbana, Ill
Washington University	6.5	Wm. H. Roever	St. Louis, Mo.
Bates College	6.25	George C. Chase	Lewiston, Me.
Students' (University of California)	6	Armin O. Leuschner	Berkeley, Cal.
Swarthmore College	6	Miss S. J. Cunningham	Swarthmore, Pa.
Knox College	6	Chas. B. Thwing	Galesburg, Ill.
Central High School	6	Monroe B Snyder	Philadelphia, Pa.
Bowdoin College	6	C. C. Hutchins	Brunswick, Me.
Creighton University	5	Wm. F Rigge	Omaha, Nebr.
Iowa University	5	L. G. Weld	Iowa City, Iowa.
Georgetown University	4.8	John G. Hagen	Washington, D. C.
Williams College	4.8	Truman Henry Safford	Williamstown, Pa.

Following this table is found a very instructive statement regarding the equipment of these observatories, a part of which follows:

Yerkes Observatory of the University of Chicago, located at Williams Bay,

Wis., George E. Hale, Director.—The Yerkes Observatory has the form of a Latin cross, the longer axis of which lies due east and west. The 90-foot dome, which contains the 40-inch telescope, is at the western extremity of the building. At the eastern extremity is the meridian room, and the 26-foot and 30-foot domes terminate the north and south transepts. The motions of the great dome, the rising floor which gives access to the telescope in all its positions, and the telescope itself, are obtained by electric motors.

The large telescope is provided with all necessary accessories, including position micrometer, solar spectroscope, steliar spectrograph, spectroheliograph, and photoheliograph. In the 26-foot dome is mounted the 12-inch refractor, formerly at the Kenwood Observatory at Chicago, the entire instrumental equipment of this institution having been donated to the Yerkes Observatory. In the 30-foot dome a 24-inch reflecting telescope is mounted. The mirror of this instrument was made by Mr. W. G. Ritchey, optician of the Yerkes Observatory. Between the small domes is the heliostat room. Within the heliostat room are the mirrors and radiometer used by Professor Nichols for his measures of stellar heat radiations. In the meridian room, a small universal instrument, now at the students' observatory, was formerly used for latitude and time observations. A 3½-inch transit instrument is available for use. The body of the building, between the domes, is divided into laboratories for physical and chemical work and offices for members of the staff.

The principal work of the Observatory, under the director, George E. Hale, includes: 1. Observations of double stars with the 40-inch telescope, by Professor Burnham. 2. Micrometric observations of star clusters, nebulæ, planets, satellites, comets, etc., with the 40 inch telescope, by Professor Barnard. 3. Photographic studies of stellar spectra with the 40-inch telescope, by Professor Hale and Mr. Ellerman. 4. Determination of the motion of stars toward or from the Earth and of the motion of the solar system in space with the 40-inch telescope, by Professor Frost and Mr. Ellerman. 5. Spectroscopic observations of the Sun and photographic work with the spectroheliograph attached to the 40-inch telescope, by Professor Hale. 6. Stellar and nebular photography with a 6-inch portrait lens, by Professor Barnard, and with the 24-inch reflecting teiescope, by Mr. Ritchey. 7. Miscellaneous spectroscopic and bolometric work. 8. Transit observations for the time service, by Mr. Adams.

Lick Observatory of the University of California, located at Mount Hamilton, California, J. E. Keeler, director.—The Observatory consists of a main building containing computing rooms, library and the domes of the 36-inch equatorial and the 12 inch equatorial, and detached buildings to shelter the Crossley reflector, the meridian circle, the transit, the horizontal photoheliograph, the portable equatorial, and the Crocker and Floyd photographic telescopes. On the ground are dwelling houses for the astronomers, students, and employees and shops for the workmen.

The Observatory is fully provided with instruments, some of which are the 36-inch equatorial objective, by Alvan Clark & Son, mounting by Warner & Swasey; this instrument has also a photographic corrector of 33 inches, figured by Alvan G. Clark; 3-foot reflecting telescope; 12-inch equatorial; 6-inch Bruce comet-seeker; 6½-equatorial mounting; 5-inch Floyd telescope; 6½ inch meridian circle; 4 inch transit; 4-inch comet seeker; 5-inch horizontal photoheliograph; Crocker photographic telescope; a spectroscope, specially adapted for photography, given by Hon. D. O. Mills for use with the 36-inch refractor; a spectroscope specially adapted for photography with the Crossley reflector, and two

photometers for use with the 36-inch and 12-inch telescopes have been provided from the proceeds of a gift from Miss C. W. Bruce, of New York City. There are, besides, many minor pieces of apparatus.

The scientific work of the Observatory is under the director, James E. Keeler. The students' observatory at Berkeley, Cal., described elsewhere, belongs to the University of California.

The general policy is to carry on investigations which cannot be pursued to so great advantage elsewhere. The observatory makes the most of its natural advantages, and extended theoretical researches, which can be made as well in a city as at a fine observing station, do not form a part of the general plan. The variety of instruments makes the field covered quite a wide one.

The principal work is devoted to spectroscopic determinations of the motions of stars in the line of sight, by Professor Campbell, assisted by Mr. Wright; and micrometric work and observations of the satellites of Neptune, Mars, and Uranus; measures of planetary nebulæ, for parallax; measures for determining a possible refractive effect on stars by the head of Swift's comet, by Professor Hussey and Messrs. Perrine and Aitkin; observations of comets, and, in the case of expected comets, for purposes of discovery; measurement and discovery of double stars, by Messrs. Hussey and Aitkin; astrophysical researches and photography of nebulæ, by Professor Keeler and Assistant Palmer; study of triple hydrogen lines, by Professor Campbell; investigation of stars in the great cluster in Hercules, by Mr. Palmer; telescopic photographs of the great nebulæ in Orion —an extension of the spectroscopic method to parts of the nebula which are too faint for visual observation; and a large variety of miscellaneous observations and computations.

United States Naval Observatory, located on Georgetown Heights, District of Columbia, Capt. C. H. Davis, U. S. N., director.—The instruments and accessories of the Naval Observatory consist of great equatorial and accessories (including elevating floor); east meridian circle (Pistor & Martens, 9-inch, remodeled); south transit instrument; prime-vertical instrument; 12-inch equatorial; 6-inch transit circle (Warner & Swasey); 5-inch alt-azimuth and building (Warner & Swasey); 1 comet seeker, 4-inch (Brashear), alt-azimuth: 1 comet seeker, 4 inch (old equatorial mounting); 13 astronomical clocks; 7 chronographs (with stands and scales); 3 personal-equation apparatuses; 2 level triers; meteorological apparatus; transit of Venus measuring engine; equipment of magnetic observatory; 1 kathetometer; instrumerts for testing sextants. Instruments unmounted: 9.6-inch equatorial, 7¾ equatorial, and Repsold transit of Venus, etc.

The instrumental equipment is for the most part new, few of the instruments of the old Observatory having been retained in their original form. An entirely new mounting has been provided for the 26-inch equatorial telescope, and the 9.6-inch telescope was replaced by a new refractor of 12 inches aperture. A large spectrograph, of modern design, was furnished for the 26-inch telescope. Two new instruments, constructed entirely of steel, were added to the equipment. One of these is a meridian circle of 6 inches aperture, and the other is a 5-inch alt-azimuth. The 8 5-inch Pistor & Martens meridian circle has been furnished with a new objective of 9.1 inches aperture and the mounting reconstructed. All the new instruments are of American make.

The Observatory work is divided into two classes, astronomical and nautical. The first includes the department of astronomical observations and the department of the Nautical Almanac. The second includes the department of nautical instruments, the department of chronometers and time service, and the de-

partment of magnetism and meteorology. A naval assistant is provided for the superintendent, and provision is made for a director of the Nautical Almanac and for heads of the various nautical departments.

On September 20, 1894, Prof. William Harkness was appointed astronomical director. On June 30, 1897, he was also made director of the Nautical Almanac, after the resignation of Professor Hendrickson, who occupied the position for a short time after Professor Newcomb's retirement on March 12, 1897.

The work of the Observatory since its removal to the new site has included observations of the Sun, Moon and planets and certain ephemeris stars (suspended from 1891 to 1894), observations of stars in the zone —13° 50′ to —18° 10′ of the *Astronomische Gesellschaft*, observations of selected stars with the prime vertical transit and the alt-azimuth, micrometric observations with the 26-inch and 12-inch telescopes. Some photographs of stellar spectra have been made with the spectrograph attached to the 26-inch telescope. The meteorological observations have been continued, but magnetic work (first seriously undertaken in 1881) has been given up, owing to disturbances caused by electric cars. Professor Yarnall's catalogue, containing the positions of all miscellaneous stars, observed with the mural circle and transit instrument between 1845 and 1877, was published in 1878 (second edition). A third edition has since been brought out by Professor Frisby. Professor Eastman's catalogue of 5,151 stars, observed between 1866 and 1891, appeared in 1898. Of this catalogue the astronomical director remarks that it "has absorbed the labors of about two-thirds of the Observatory staff for more than thirty years."

Observing Stations for the Total Eclipse, May 28.—Professor Geo. E. Hale, Director of the Yerkes Observatory sends us the following note:

"The following list of stations to be occupied by eclipse parties is complete to date. I have not yet received replies from some of the most important institutions.

Norfolk, Va., National Geographic Society; Near Norfolk, Va. or Raleigh, N. C., Winslow Upton and party; Intersection of central line with Southern Railway, S. E. of Raleigh, N. C., C. W. Edwards and party; Wadesboro, N. C., parties of the Smithsonian Institution, Yerkes Observatory, Princeton University, and the British Astronomical Association; Newberry, S. C., U. S. Weather Bureau; At or near Macon, Ga., C. W. Crocket; Union Point, Ga., Charles Burckhalter; Thomaston, Ga., Lick Observatory; Brownsville, Ga., University of Virginia. (I have received this information at second hand); Washington, Ga., A. L. Rotch and party; Greenville, Ala., W. H. Pickering and party; Near Mexican Central Railway, Rose O'Halloran.

Professor Brown, Astronomical Director of the Naval Observatory, has not yet replied to the circular letter, but Professor See states that a number of parties will be sent out, one of which will go to Mexico. I have also learned that Professor Ames, of the Johns Hopkins University, Professor Crew, of the North-Western University, and Professor Lord, of the Ohio State University, will coöperate with the Naval Observatory. The Allegheny Observatory, Vassar College Observatory, and several other institutions will send out eclipse parties, but I do not now know what sites they will select." GEORGE E. HALE,

Secretary, Eclipse Committee.

Miss Rose O'Halloran will Observe the Total Eclipse in Mexico.—Miss Rose O'Halloran, of San Francisco, vice president of the Astronomical Society of the Pacific, will leave for Mexico about the middle of April to observe the total solar eclipse of May 28, 1900. After observing the southern variable stars for some weeks, as far south at least as the City of Mexico, Miss O'Halloran will travel northward about May 20, to the track of the lunar shadow, near the Mexican railway.

Her eclipse work will be carried on with unpretentious equipment. As the

larger instruments of other observing parties from California and elsewhere will be used in positions further eastward in the United States, it has seemed to Miss O'Holloran wisely desirable to make photographic and visual observations near the western end of the path of totality.

The plan of Miss O'Holloran's work is to take a few photographs of the inner corona with a 4-inch Brashear refractor of six feet focal length, having a plate-holder and shutter in the focal plane of the telescope. The remaining time will be given to visual observations of the structure of the outer corona, and a drawing will be made when the total phase is ended.

As a mere experiment, a 2½-inch portrait lens will be tried for one second just before totality, and again, having reversed the plate-holder, will expose a plate for half a minute after totality. May favoring circumstances aid Miss O'Halloran's well-planned work.

The Lick Observatory Total Eclipse Expedition.—By the generosity of Mr. William H. Crocker, of San Francisco, the Lick Observatory will be able to send a party to Georgia, to observe the total solar eclipse of May 28. Only two observers, Messrs. W. W. Campbell and C. D. Perrine, will be sent out from the Observatory; but several European astronomers have expressed a desirs to join the party, and similar requests have also been received from astronomers connected with American colleges which do not intend to send out expeditions of their own.

The instrumental equipment of the expedition will be quite complete. The principal instrument for photographing the corona will be the 5-inch telescope of 40 feet focal length, used by the Lick Observatory parties in South America and India. For photographing the corona on a smaller scale there will be several cameras of from five to six inches aperture, and others of smaller size. One slit spectrograph, and two objective spectrographs arranged to give a continuous record of the changing spectrum at the beginning and end of totality, are also included in the equipment. Observations of contacts will be made.

Any observers, having experience in astronomical or physical work, who wish to join the party at their own expense, like the gentlemen referred to farther above, are invited to communicate with the Director of the Lick Observatory before April 20, and after that date with Professor W. W. Campbell, Lick Observatory Eclipse Expedition, Atlanta, Georgia.

Queries and Short Answers.—8. What is the date and the path of totality of the next total solar eclipse visible in the United States. D. S.

Answer. The following letter by favor of H. D. Todd, Professor of Mathematics, U. S. A., and Director of the Nautical Almanac, answers the query:

SIR:—I have the honor to state, in reply to your letter of the 2d instant, referred to this Office by the Naval Observatory, that the next total solar eclipse visible in the United States after that of May 28, 1900, will occur in 1918, June 8, G. M. T. This eclipse will commence in the Pacific Ocean, off the coast of China, and the central path will enter the United States at our extreme northwest corner, and follow approximately a path through the States of Washington, Idaho, Wyoming, Nebraska (the south-west corner), Kansas, Arkansas, Mississippi, Alabama and Florida, ending soon after it reaches the Atlantic Ocean.

I beg leave to add that there will also be a total eclipse of the Sun in 1905, August 30, not visible in the United States, but very near, commencing just north of the boundary line between Minnesota and North Dakota. The shadow path of this eclipse will pass nearly due east, turning slightly to the north, and will enter the Atlantic Ocean from the southern part of Labrador.

Very respectfully,

H. D. TODD,
Professor of Mathematics, U. S. N.,
Director, Nautical Almanac.

NAUTICAL ALMANAC OFFICE,
GEORGETOWN HEIGHTS, D. C.,
April 12, 1900.

9. I want an accurate up-to-date star map, one that shows Right Ascension and Declination correctly. Where can I get it? W. J. L.

Answer. Professor Winslow Upton, has recently prepared a first rate Star Atlas with useful descriptive matter and a set of excellent star maps. The star places on these maps are reduced to 1900. Messrs. Ginn & Company, of Boston or Chicago are the publishers of this Star Atlas.